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REMOTE SENSING STUDY, EASTERN FLORIDA COAST, DADE COUNTY, FLORIDA

National Field Investigations Center
Denver, Colorado

April 1972

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ENVIRONMENTAL PROTECTION AGENCY
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PB 229807

REMOTE SENSING STUDY

EASTERN FLORIDA COAST
DADE COUNTY, FLORIDA

NATIONAL FIELD INVESTIGATIONS CENTER-DENVER
DENVER, COLORADO
AND
REGION IV, ATLANTA, GEORGIA

AUGUST 1972

CLEAN WATER

PB 229 807

ENVIRONMENTAL PROTECTION AGENCY

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REMOTE SENSING STUDY
EASTERN FLORIDA COAST
DADE COUNTY, FLORIDA

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NATIONAL FIELD INVESTIGATIONS CENTER-DENVER

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APRIL 1972

TABLE OF CONTENTS

	Page
LIST OF FIGURES	ii - iii
INTRODUCTION	1
SUMMARY	2
RECOMMENDATIONS	3
MISSION PURPOSE	4
STUDY AREA	5
CHRONOLOGICAL DATA	7
AIRCRAFT SENSOR DATA	8
RESULTS OF AERIAL RECONNAISSANCE INTERPRETATION	
SOUTH EASTERN FLORIDA COASTAL REGION	13
MAPPING THE OCEAN BOTTOM	19
DROGUE STUDY	20
MIAMI RIVER	22
WEST 4th AVENUE CANAL	25
CARD SOUND	26
APPENDIX	27

LIST OF FIGURES

Figure No.	Title
1.	Map of the South East Coast of Florida
2.	Map of the Miami River
3.	Map of the West 4th Avenue Canal
4.	Map of Turkey Point and Card Sound
5. A.	Framing Camera
B.	Field of View of the Framing Camera
6.	Low Altitude Panoramic Camera
7. A.	Optical System of the IRLS
B.	Field of View of the IRLS
8.	Lake Worth Inlet
9.	West Palm Beach Canal
10.	South Lake Worth Inlet
11.	Delray Beach Sewage Outfall
12.	Boca Raton Sewage Outfall
13.	Boca Raton Inlet
14.	Hillsborough Inlet
15.	Pompano Beach Sewage Outfall
16.	Port Everglades
17.	Port Everglades
18.	Hollywood Sewage Outfall
19. A.	North Miami Beach Sewage Outfall
B.	North Miami Beach Sewage Outfall
20.	Bakers Haulover Inlet

LIST OF FIGURES (CONT'D)

Figure No.	Title
21.	Miami Beach Sewage Outfall
22.	Miami Sewage Outfall
23.	Miami Sewage Outfall
24. A. through H.	Cosmetic Features of the Ocean Bottom
25.	Diagram of the Drogues
26.	Drogue Vector Chart
27.	Turkey Point Power Station and Discharge Canal
28.	Turkey Point Power Station's Discharge Canal

REMOTE SENSING STUDY
EASTERN FLORIDA COAST
DADE COUNTY, FLORIDA

INTRODUCTION

The July 1971 meeting of the Dade County, Florida Enforcement Conference requested the Lower Florida Estuary Study Office of EPA to conduct studies of ocean outfalls to develop and recommend ocean disposal crieteria. In October 1971, EPA, Region IV, requested the National Field Investigations Center-Denver to assist in an aerial photo survey of the southeastern coast of Florida. The express purpose of the mission was to trace outfall plumes and map offshore reefs. In the planning stage the request was expanded to include aerial reconnaissance of the Miami River, West 4th Avenue Canal, and Card Sound, which is directly South of Biscayne Bay.

The aerial reconnaissance mission was flown on March 3, 1972. As this report developed, draft copies were furnished to the Lower Florida Estuary Study Office of EPA which provided valuable information for its completion.

SUMMARY

The surface plumes from the seven major inlets and from seven of the nine ocean sewage outfalls located along the southeast coast of Florida were traced and mapped. The mapping of the ocean bottom was limited to plotting the dark-toned cosmetic features. A general classification was made of the water quality in the Miami River and West 4th Avenue Canal. Twelve outfalls or sources of pollution were detected in the Miami River. Alterations to Card Sound resulting from the construction of the effluent canal from the Turkey Point Power Station were reported. The high quality imagery recorded for this study establishes a visual data base of Card Sound prior to the activation of the canal. The drogue study, associated with the Hollywood Sewage Plant outfall, indicated that ocean currents may be carrying effluent from the outfall in a northerly direction and towards the coast.

RECOMMENDATIONS

Southeastern Coast of Florida

Winds, tides, and ocean currents affect the dispersal patterns of the effluent from the major inlets and sewage outfalls. To record the variation, aerial reconnaissance should be scheduled to coincide with the different, but normal, ocean conditions. At the same time, drogue studies carried out at each outfall would provide documentation of dispersal currents. On-site tests should be made so that the depth of the drogues would be the same as the heavier concentrations of sewage effluent. The drogue monitoring should not be terminated until tests show significant dispersal of the effluent has occurred.

Card Sound

This study area should be flown at regular intervals after the Turkey Point Power Station discharge canal is put to use. Comparison with imagery recorded on these future flights with that of this mission will permit the monitoring of biological or physical changes, if any, to the bottom of Card Sound.

MISSION PURPOSE

The main objectives of the March 3, 1972 aerial reconnaissance were:

The Southeast Florida Coast from Palm Beach to Biscayne Bay

1. Determine outflow patterns associated with all sewage outfalls and inlets.
2. Map the ocean bottom, particularly in the vicinity of sewage outfalls, identifying areas of coral reefs, sand, rocks, mud, and biological and vegetative aquatic growth on the bottom strata.
3. Record any apparent variation in coral reefs and aquatic growth beds with precise references to the nearest sewage outfall.

Drogue Study

4. Establish the speed and direction of the ocean's currents at depths of 10, 30, and 60 feet, with the Hollywood Sewage outfall as the starting point.

Miami River and West 4th Avenue Canal

5. Locate and identify industrial and municipal outfalls and any other probable source of pollution entering these waterways.

Card Sound

6. Record excavations and spoil deposits on the bottom of Card Sound caused by the construction of the discharge canal from Florida Power and Light Company's Turkey Point Nuclear Power Station.
7. Establish baseline data prior to activation of this canal. Comparison of imagery from this study with that of future studies may serve to determine biological and physical changes that occur in Card Sound.

STUDY AREA

Southeast Florida Coast

Along the southeast Florida coast, from Palm Beach to Biscayne Bay, there are seven major inlets and nine ocean sewage outfalls. Figure 1 is a map of this area identifying the seven inlets covered in this study. Listed from North to South, they are:

Lake Worth Inlet

South Lake Worth Inlet

Boca Raton Inlet

Hillsborough Inlet

Port Everglades

Baker Haulover Inlet

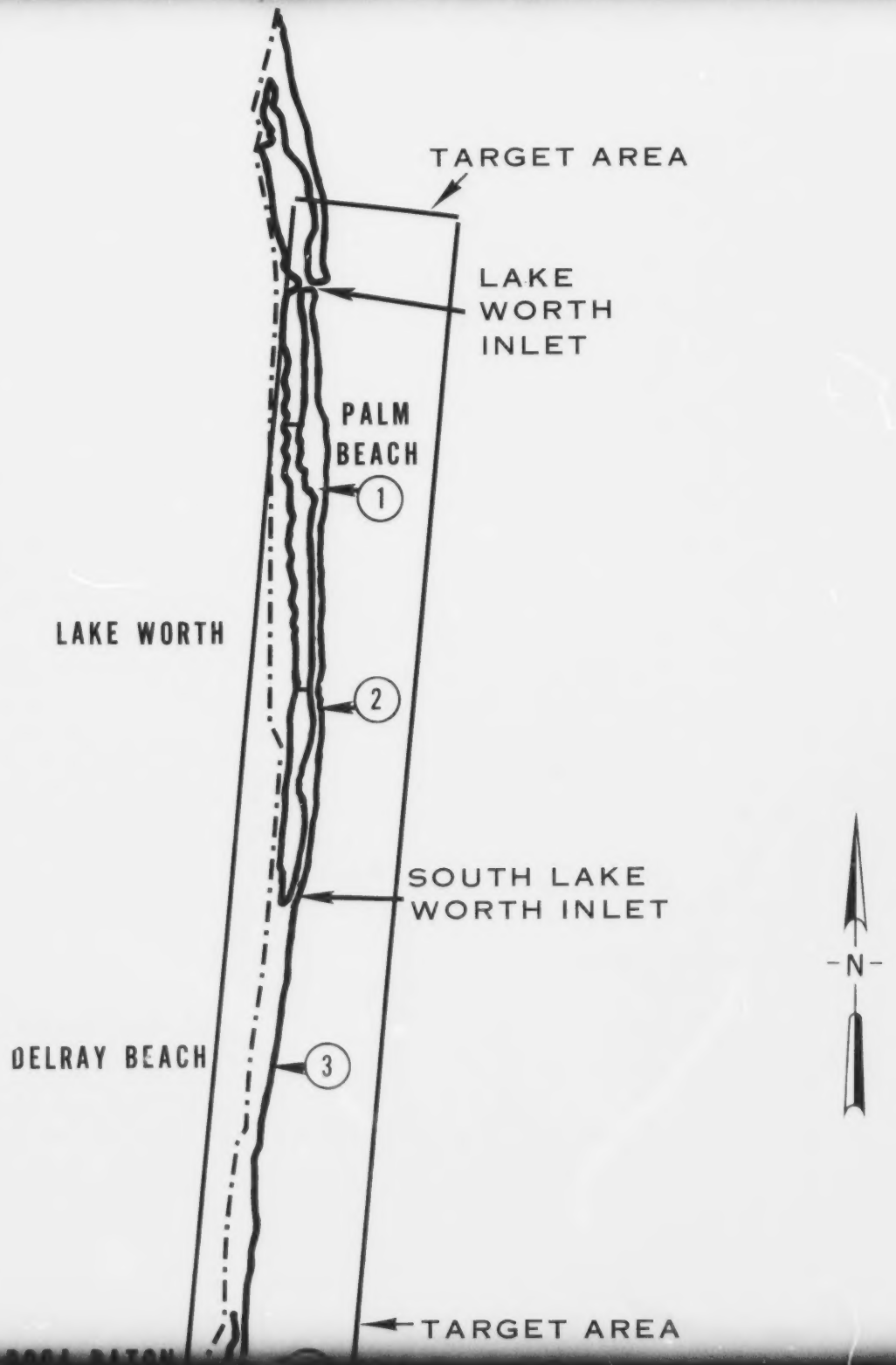
Government Cut (the entrance to Miami Harbor)

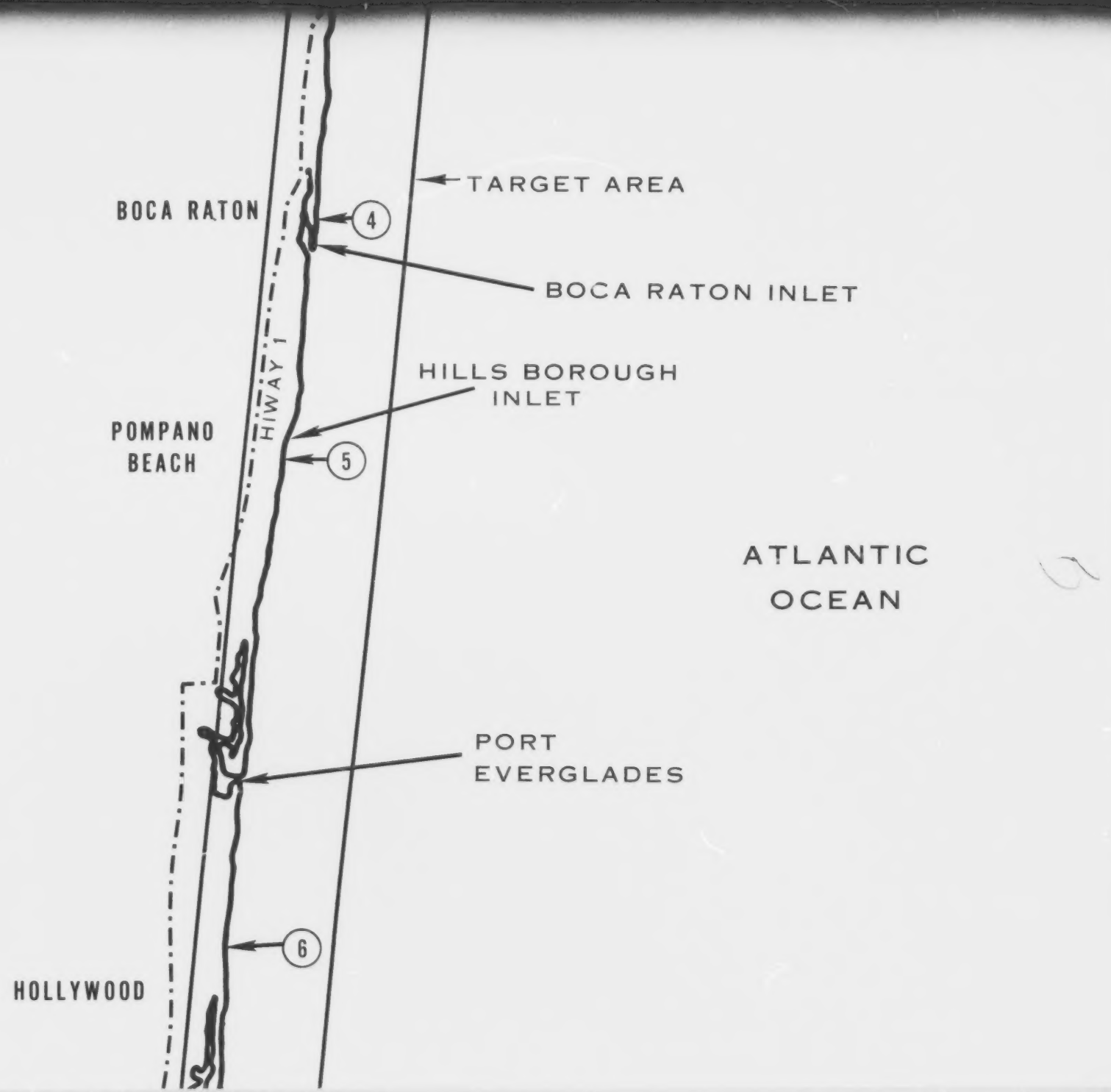
The nine ocean sewage outfalls are also located on the map, and are identified by the number corresponding to the one on the following description of these outfalls. They too, are listed from North to South.

Number		Diameter (inches)	Length (feet)	Depth at Point of Discharge	Sewage Flow (mgd)
1	Palm Beach	30	5,800	65	3
2	Lake Worth	30	5,200	90	3
3	Delray Beach	30	5,100	94	2
4	Boca Raton	36	5,500	110	8
5	Pompano	30	7,600	90	2.7
6	Hollywood	60	9,700	90	13
7	North Miami	36	10,000	65	7
8	Miami Beach	36	7,000	140	30
9	Miami	90	4,600	18	41

Drogue Study

The Hollywood Sewage Outfall was selected as the release point for the drogues.


TARGET AREA
LAKE
WORTH
INLET
PALM
BEACH
1
LAKE WORTH
2
SOUTH LAKE
WORTH INLET
DELRAY BEACH
3
N
TARGET AREA


TARGET AREA
BOCA RATON
4
BOCA RATON INLET
HILLS BOROUGH
INLET
HIWAY 1
POMPANO
BEACH
5
ATLANTIC
OCEAN
PORT
EVERGLADES
6
HOLLYWOOD

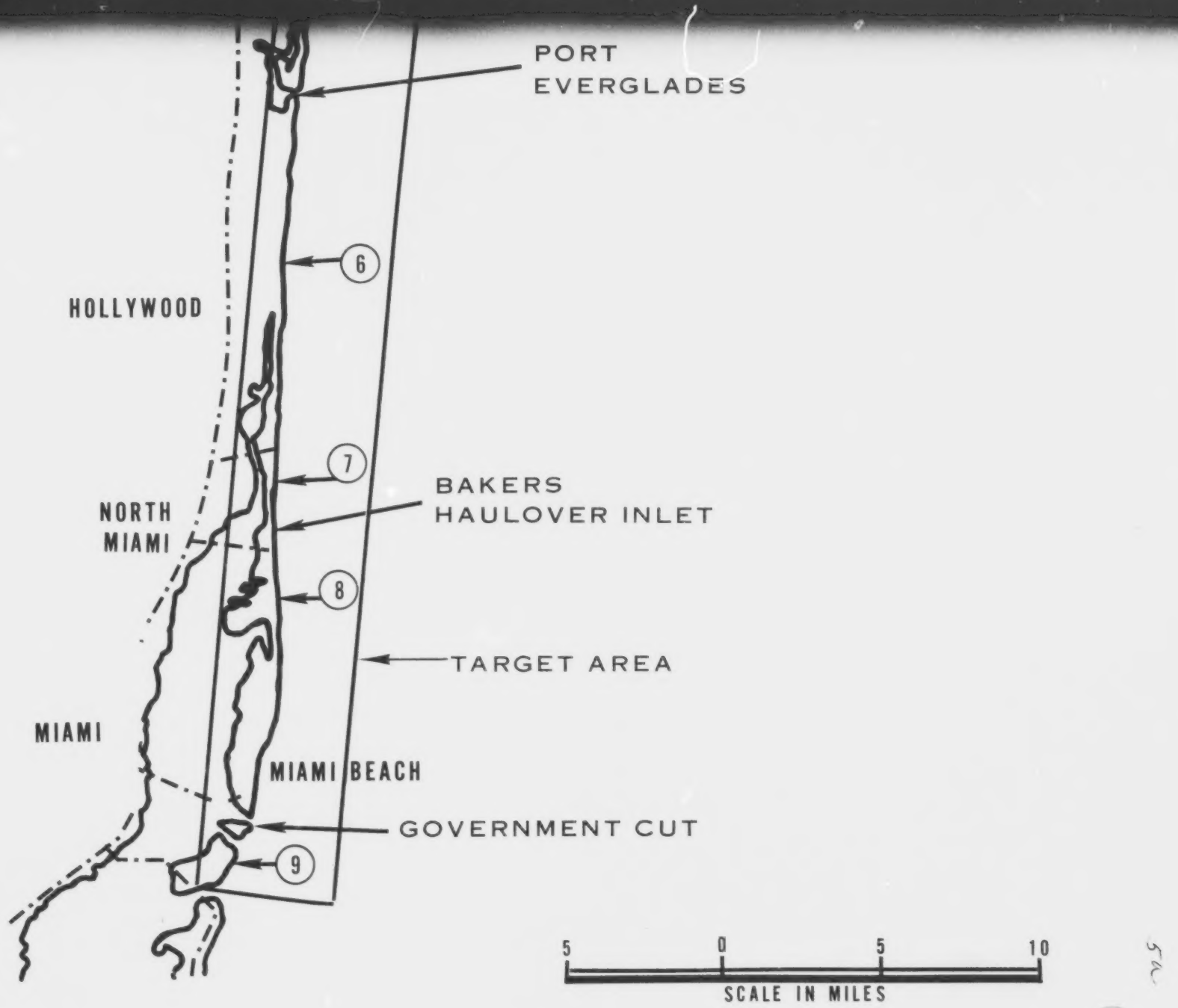


Figure 1. Eastern Florida Coastal Region

MIAMI RIVER

Figure 2 is a map showing the study area of the Miami River. The area starts at the mouth of the Miami River in Biscayne Bay and extends upriver for 7.7 miles to the Curtis Parkway Bridge.

West 4th Avenue Canal

Figure 3 shows the study area of this canal. It starts at the Miami River near the intersection of West 4th Avenue and West 9th Street, and extends North for 4.2 miles to West 77th Street.

Card Sound

Figure 4, which is also a map, shows the location of Card Sound and the Turkey Point Canal. The prime study area is where the Canal enters Card Sound and extends into the Sound for a radius of 3 miles.

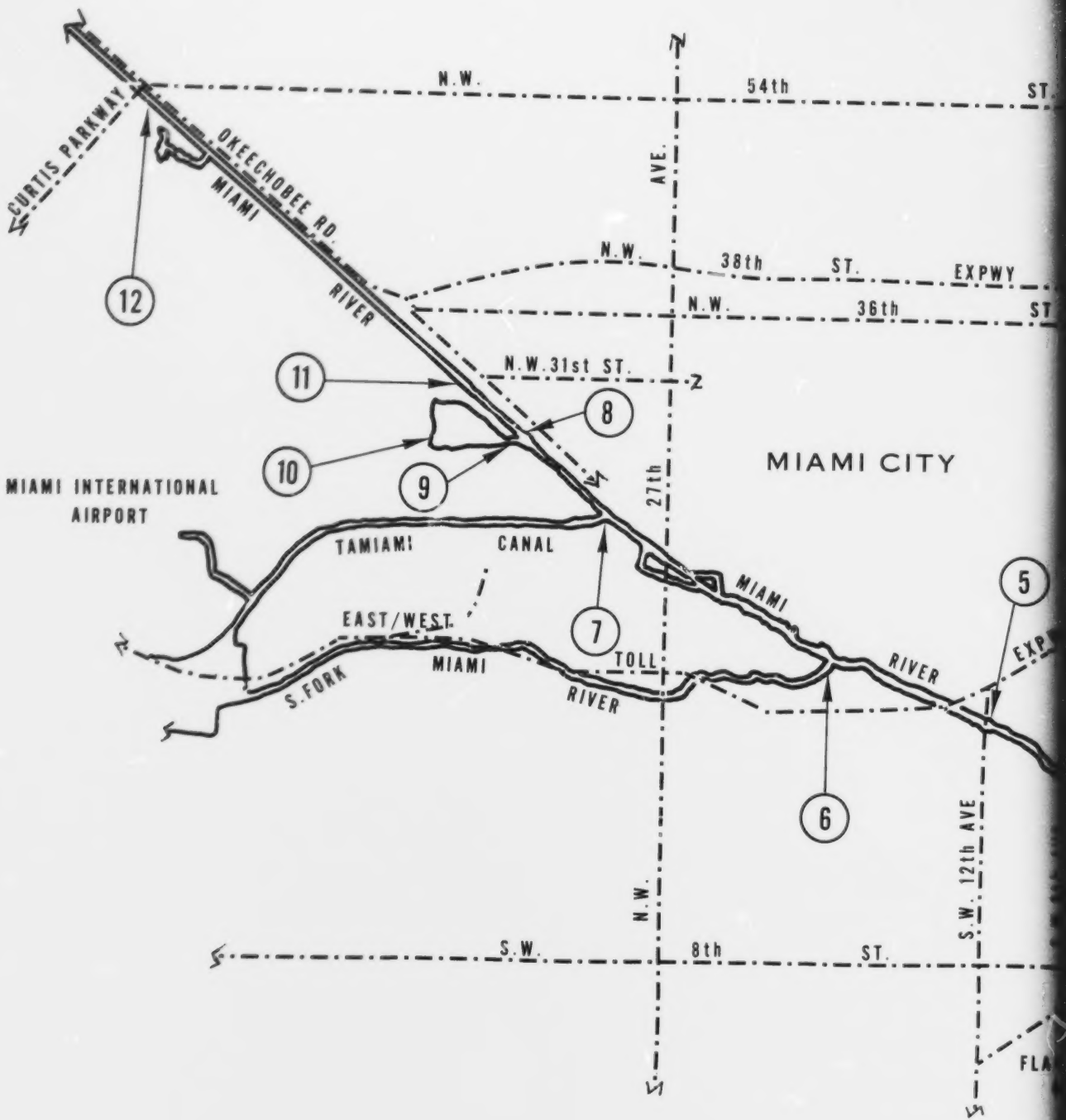


Figure 2. Miami River

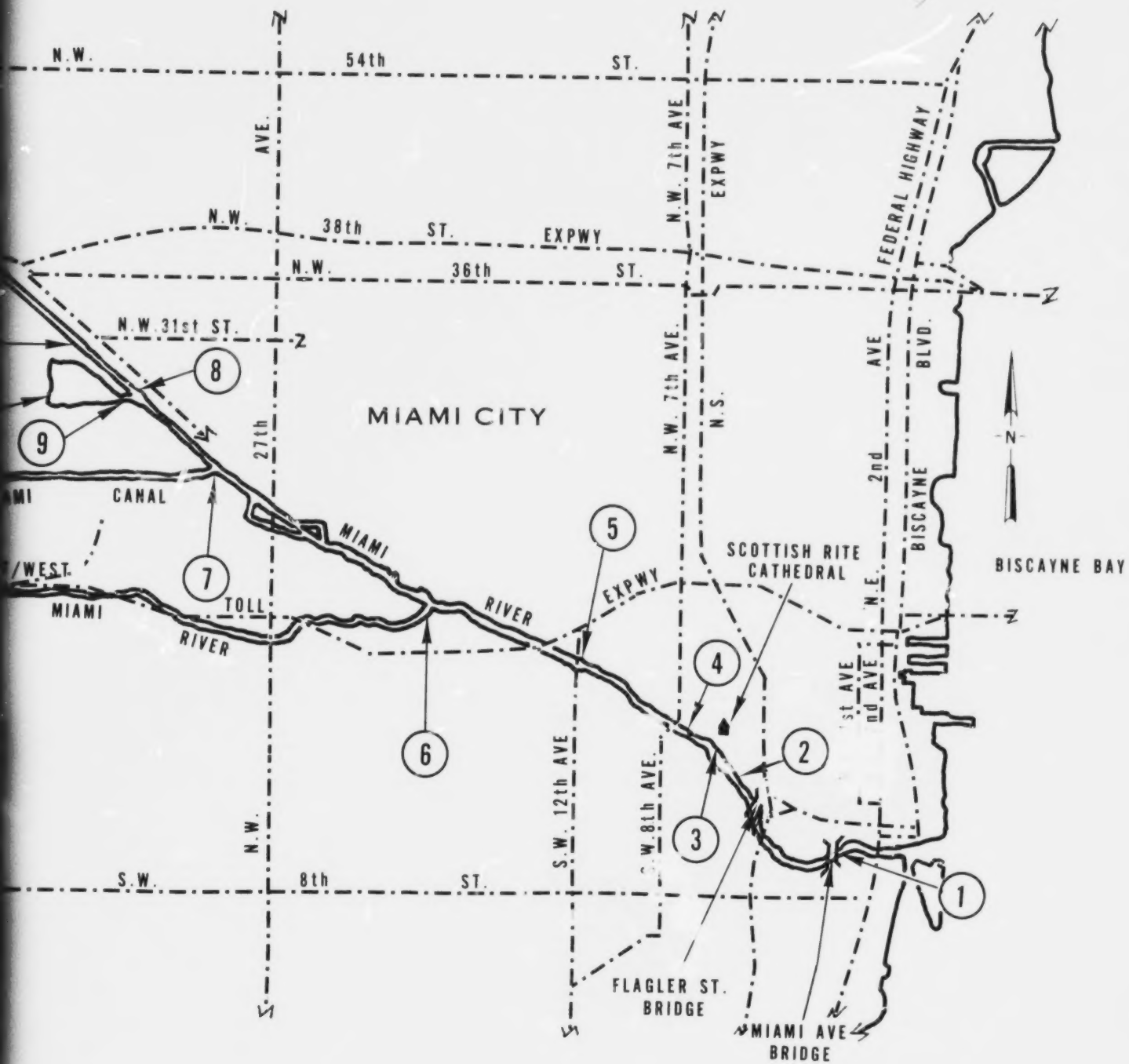


Figure 2. Miami River

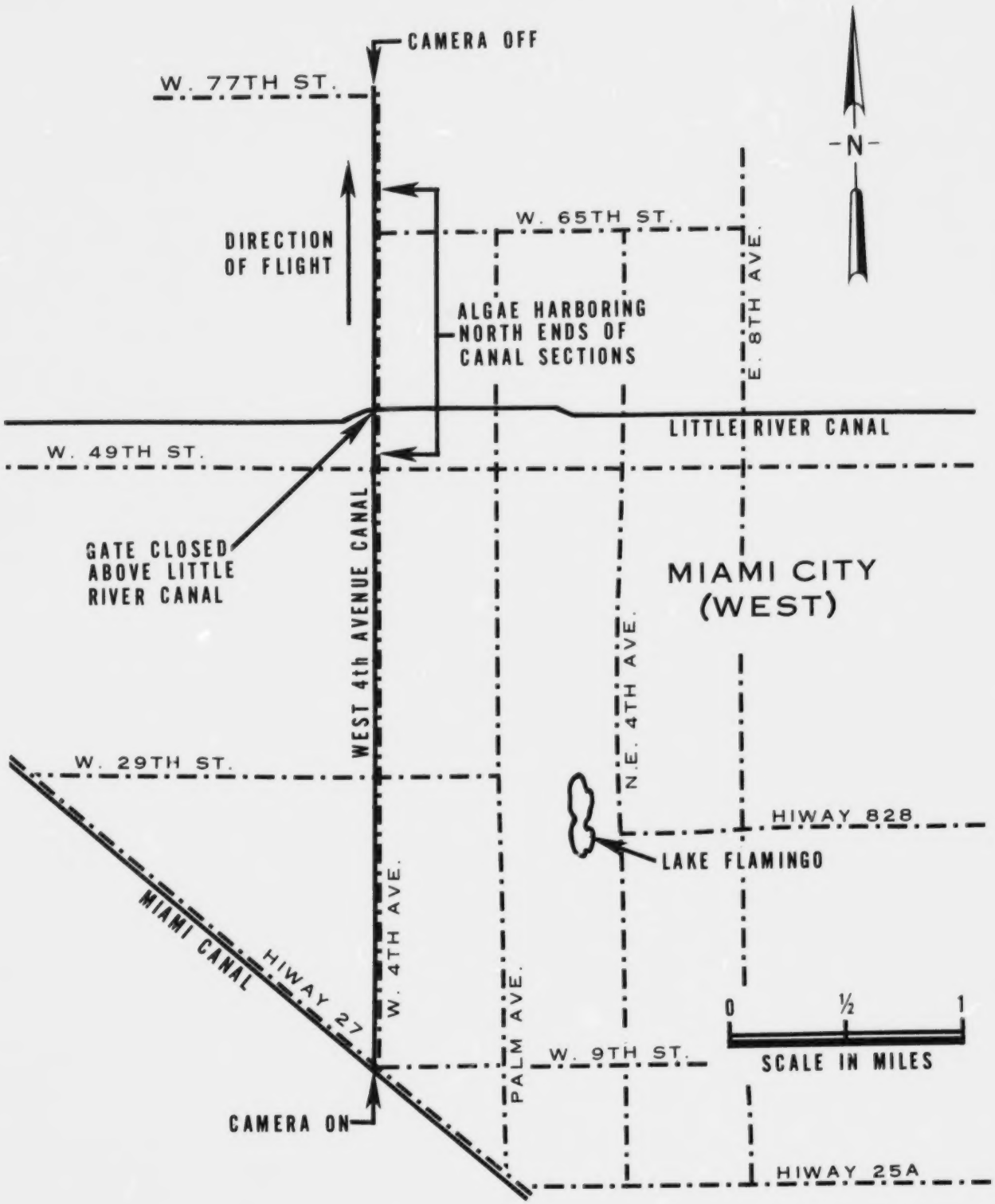


Figure 3. West 4th Avenue Canal

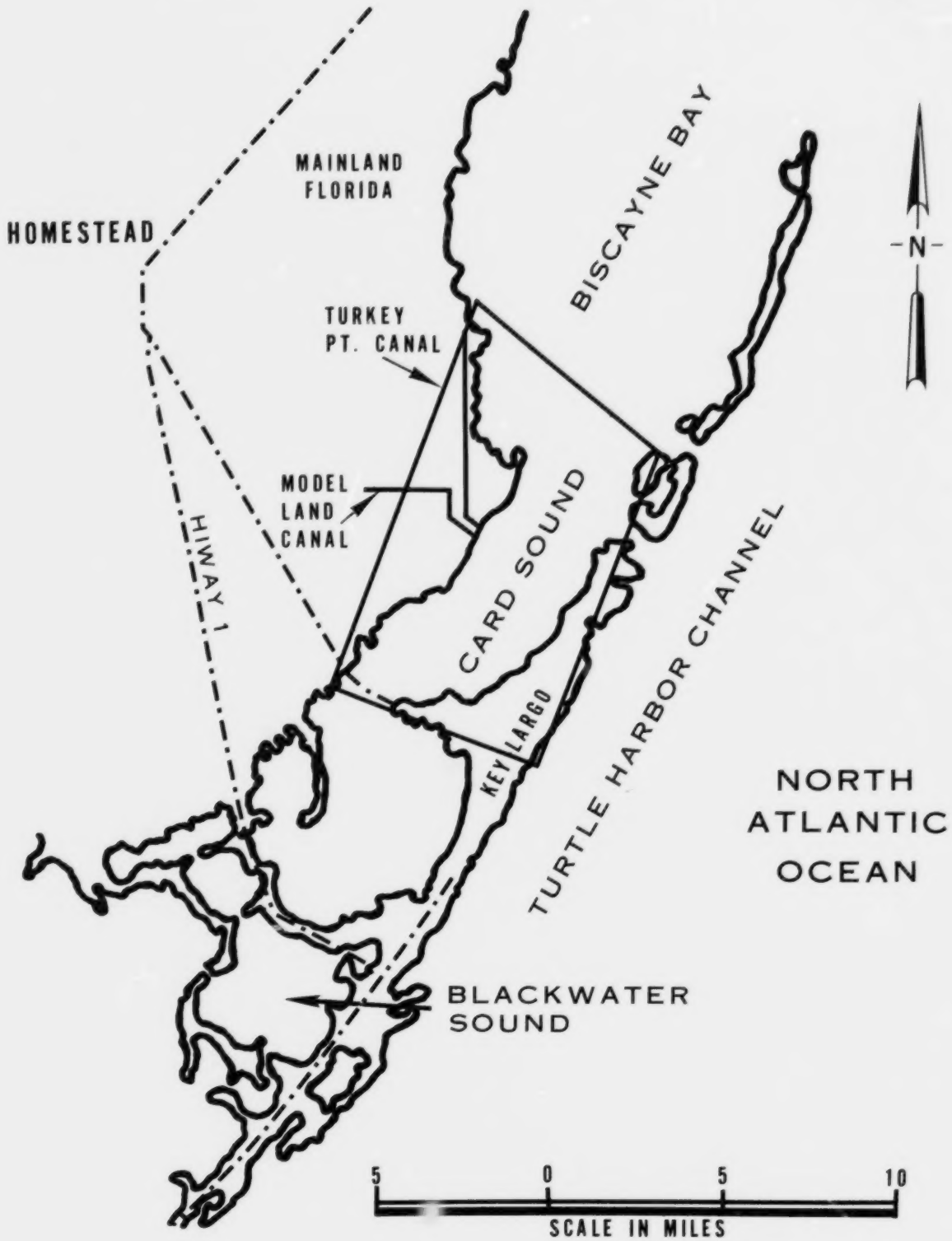


Figure 4. Turkey Point Hydro-Thermal Electric Plant Hot Effluent Discharge Canal

CHRONOLOGICAL DATA

The entire reconnaissance data was recorded on March 3, 1972, between the hours 1100 and 1250 hours EST.

SOUTH EASTERN FLORIDA COASTAL REGION

Three aircraft at 4,000 feet above sea level provided complete coverage of the target area. Sensors aboard these aircraft recorded imagery for the mapping of the ocean bottom and the study of all ocean sewage outfalls and inlets. The scale of the imagery recorded at this designated altitude was 1:8,000 for the framing camera,[1/] 1:16,000 for the panoramic camera,[1/] and 1:41,700 for the Infrared Line Scanner (IRLS).[1/]

One aircraft flying at 1,500 feet above sea level recorded the required imagery for the special drogue study conducted in the vicinity of the Hollywood sewage outfall. The scale of the imagery flown at this altitude was 1:3,000 for the framing camera and 1:6,000 for the panoramic camera. The IRLS was not required for this study.

Miami River and the 4th Avenue Canal

The single aircraft used was restricted to an altitude of no lower than 3,000 feet above ground level by the Federal Aviation Agency. The scale of the imagery at this designated altitude was 1:6,000 for the framing camera, 1:12,000 for the panoramic camera, and 1:31,300 for the IRLS.

CARD SOUND

The same aircraft which flew the Miami River and the 4th Avenue Canal also flew Card Sound. There were no flight restrictions in this area, but 3,000 feet was a practical altitude for this study.

1/ See section on Aircraft Sensor Data.

AIRCRAFT SENSOR DATA

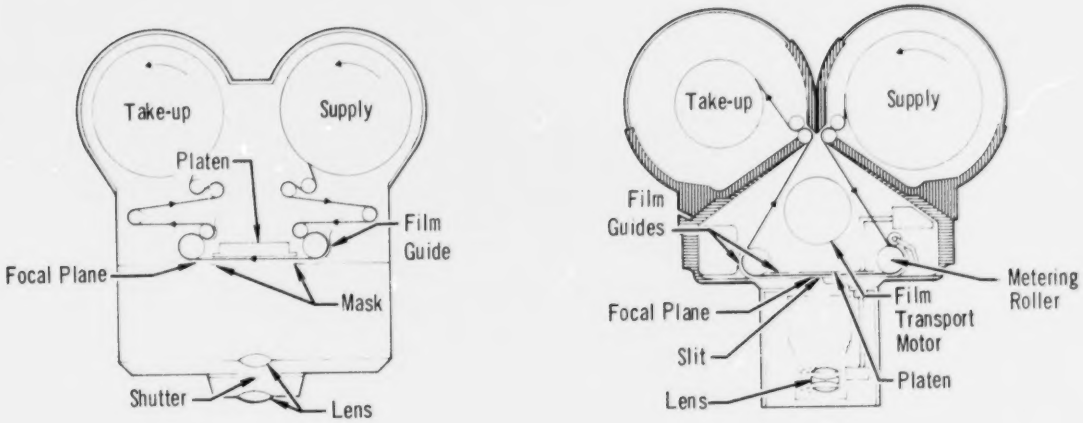
The aerial sensors carried in this remote sensing mission consisted of three cameras and an Infrared Line Scanner. The differing focal length and field-of-view of each instrument was considered and used to advantage in the planning and conduct of the mission.

FRAMING CAMERAS

Two KS-87 aerial framing cameras, with a 6-inch focal length, were used on the mission. It is noted the KS-87 may also be configured for 3-inch, 12-inch, or 18-inch focal lengths. On the mission, all sensors were mounted in their respective vertical positions. The framing cameras were uploaded with different film and optical filter combinations. True color and false color infrared imagery was obtained as follows:

- Using aerographic ektachrome Kodak SO-397 film with a Wratten HF-3/HF-5 filter combination, the visible region of the optical spectrum was recorded, resulting in true color transparencies.
- Using Kodak 2443 aerographic film with a Wratten 16 gelatin optical filter, a portion of the visible spectrum, i.e., red, orange, was overlapped with the near infrared region of the optical spectrum, giving false color rendition transparencies.

A typical framing camera is shown in Figure 5A. Figure 5B shows the field-of-view of a framing camera from the position of the aircraft.



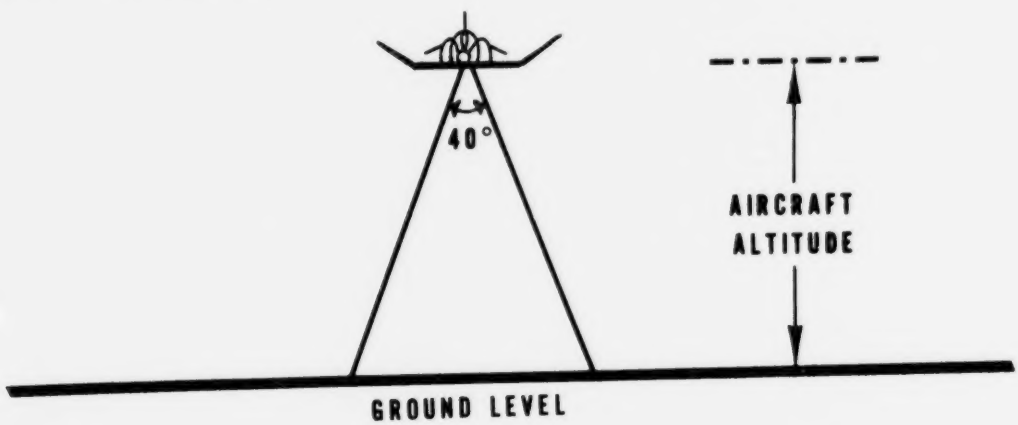
Film Advances Frame by Frame
Framing Camera

Film in Continuous Motion
Continuous Strip Camera

Figure 5A

(c) Near infrared region of the optical spectrum which was overlapped with a portion of the visible spectrum (red, orange), resulting in an aerographic ektachrome 4.5" X 4.5" false color (rendition) transparency - Kodak 2443 aerographic film with a Wratten 16 gelatin optical filter.

This viewing angle of each camera was 41° about the aircraft's nadir as shown below:



Viewing Angle of a Framing Camera Configured with a 6 inch Focal Length.

Figure 5B

Low Altitude Panoramic Camera

One KA-56 camera, low altitude panoramic (LAP), was used. The KA-56 has a 3-inch focal length and uses a rotating prism for scanning horizon to horizon a full 180°. When the flight path of the aircraft was over water, but within sight of land, the LAP camera recorded prominent shore features. From these features the precise flight path of the aircraft could be plotted. From the flight line plot the exact area of the ocean imaged by the framing camera was determined. The LAP camera was uploaded with standard black and white panchromatic film.

A typical rotating prism panoramic camera is shown in Figure 6.

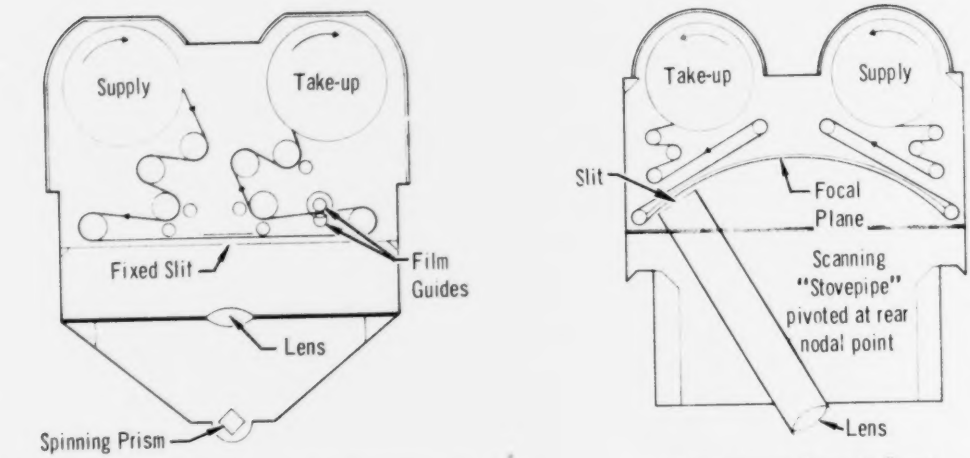


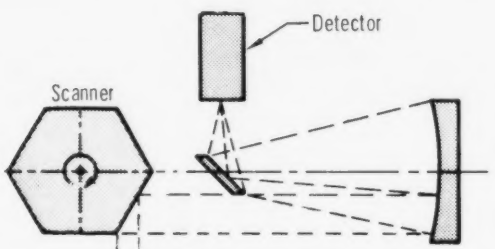
Figure 6

Infrared Line Scanner

An infrared line scanner (IRLS) which records a thermal map of an imaged area completed the array of airborne sensors used on this mission. The IRLS uses an infrared detector and an electro-optic

system to record on film the amount of infrared energy dectected in the imaged area. The effective focal length of the AAS-18 is 1.15 inches and the field of view is 120°.

The three basic units in an infrared reconnaissance set are scanner optics, a detector, and a recording unit. The scanner picks up the infrared emissions from the ground and reflects them to a parabolic mirror. The parabolic mirror focuses the infrared emissions onto the detector. The detector converts the infrared energy collected by the scanner into an electrical signal. In the recording unit the electrical signal is converted to visible light which is then recorded on ordinary black and white film. Figure 7A depicts optical system of the IRLS. Figure 7B shows the field-of-view of the IRLS from the position of the aircraft.



B. Basic Two-Sided Coaxial Rotating Mirror Optical System

Figure 7A

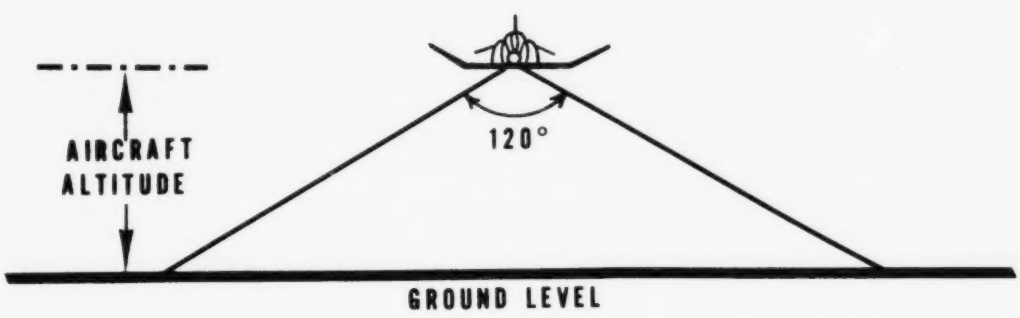


Figure 7B Field-of-View of the IRLS.

The Appendix contains information pertinent to aerial sensors in respect to:

- Focal length
- Angle of view
- Effects of focal length and altitude on scale and ground coverage.

RESULT OF AERIAL RECONNAISSANCE INTERPRETATION

South Eastern Florida Coastal Region

The inland waterways along the Florida coast are relatively shallow and affected in varying degree by tides and coastal currents. As expected, the inland waterways were significantly warmer than the coastal ocean waters, and this difference was principally recorded on the IRLS imagery. Either the camera imagery or the IRLS imagery was used for measurements depending upon which gave the most clearly defined data. Findings are presented below for major areas including inlets, terminus of discharge of submerged sewage lines into the Atlantic, and other important features.

Lake Worth Inlet

This inlet, shown in Figure 8, is the interconnecting waterway between Lake Worth and the Atlantic Ocean. This waterway is maintained at a depth of 33-35 feet and is approximately 700 feet wide. The IRLS imagery recorded the outflow into the Atlantic Ocean as a warm thermal plume. The plume maintained a definite boundary from the inlet for some 1,400 feet east and then curved Northward. Filling the inlet as it entered the ocean, the plume expanded as it moved outward and northward attaining a width of around 2,000 feet, at which point the imagery terminated one mile North of the inlet.

Palm Beach Sewage Outfall

The terminus for this sewage outfall is 5,800 feet from the coast and at a depth of 65 feet. An effluent plume could not be seen in either the optical or infrared imagery.

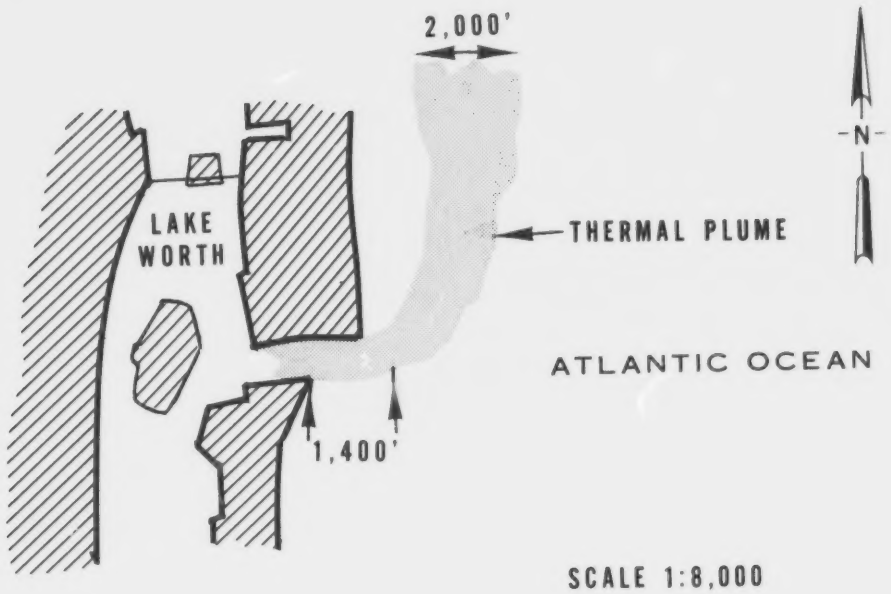


Figure 8 Lake Worth Inlet

West Palm Beach Canal

This canal is approximately 41 miles long and connects Lake Okeechobee and Lake Worth. The water from the Canal created a small warm plume as it entered Lake Worth. This plume flowed Northward and was dispersed within 160 feet from its source (Figure 9).

Lake Worth Sewage Outfall

The terminus for this sewage outfall is 5,200 feet from the coast and at a depth of 90 feet. Once again, neither the optical or infrared imagery recorded a visable effluent plume.

South Lake Worth Inlet

This inlet is shown in Figure 10 and is the waterway connecting the south end of Lake Worth with the Atlantic Ocean. The infrared imagery recorded a warm plume that achieved a width of 520 feet as it flowed approximately 1,500 feet out into the ocean. This plume then turned Northward for 700 feet before it cooled sufficiently to lose its identity.

Delray Beach Sewage Outfall

The terminus for this outfall is 5,100 feet from the coast and at a depth of 94 feet. Figure 11 shows the effluent plume on the surface of the ocean. As the discharge from the sewer reaches the surface of the ocean, an upwell area 20 feet x 30 feet is created. From the upwell area, a plume rapidly spreads to 250 feet wide as it moves Northward parallel to the coast for 1,650 feet. At this point the effluent had dispersed to such an extent that it no longer could be seen.

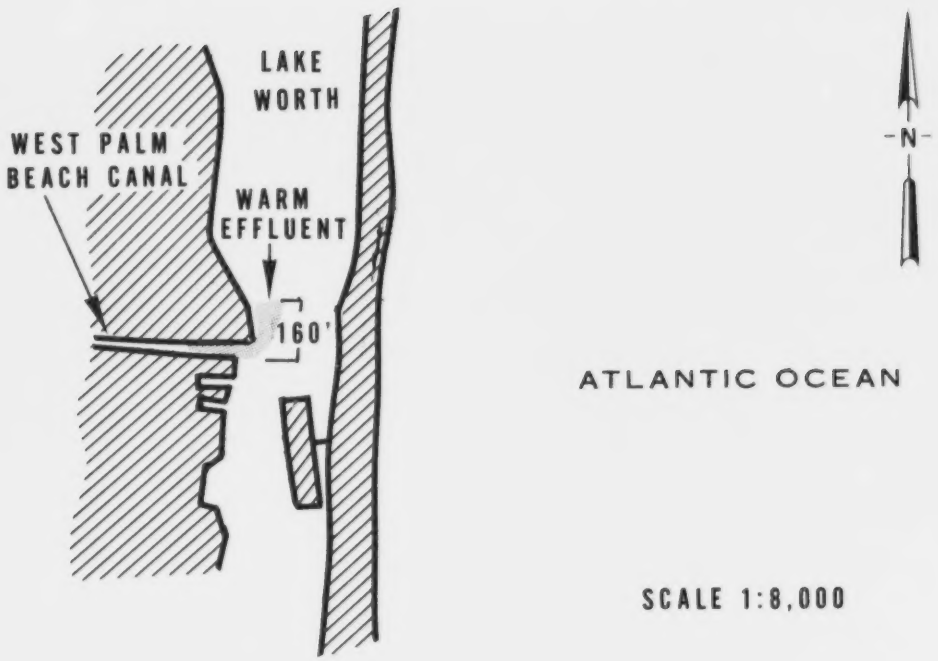


Figure 9 West Palm Beach Canal

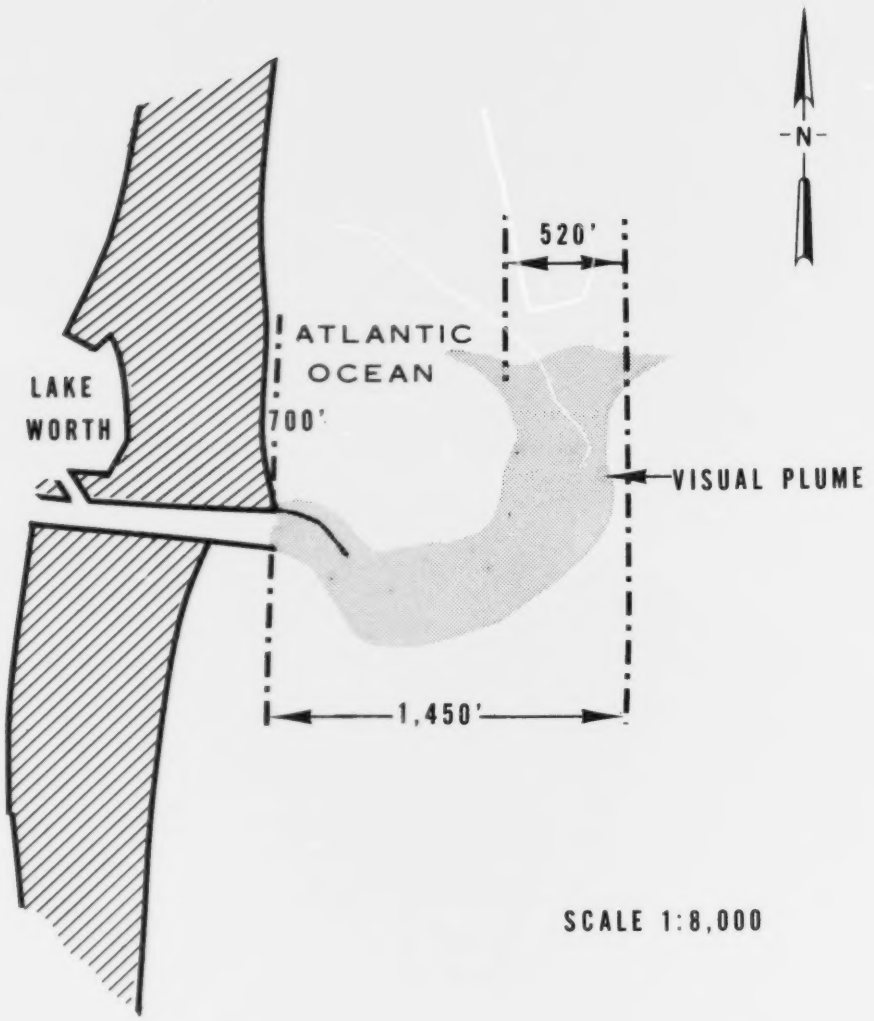


Figure 10 South Lake Worth Inlet

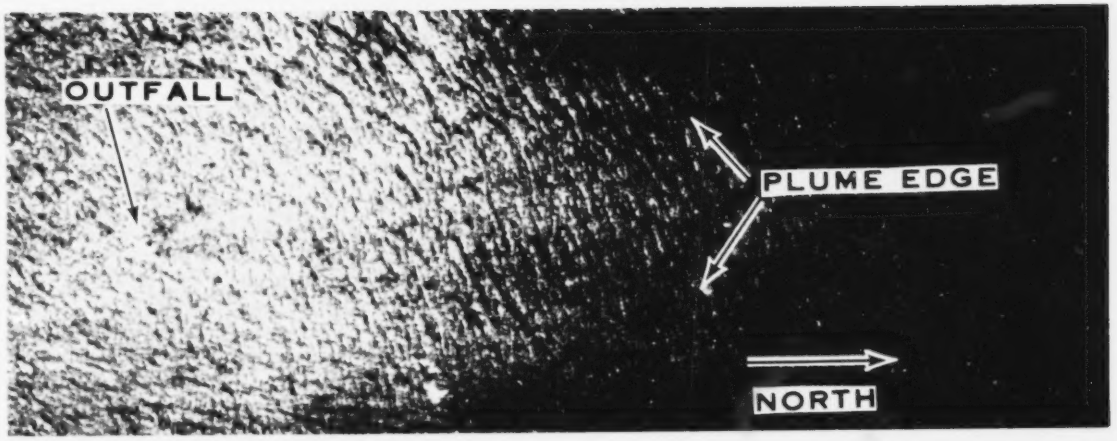


Figure 11 -Delray Beach Sewage Outfall

Approximate scale 1:10,000

Boca Raton Sewage Outfall

The terminus for this outfall is 5,500 feet from shore and at a depth of 110 feet. The 30-foot-by-40-foot oval pattern where the effluent from this outfall reaches the ocean surfece can be seen in Figure 12. The effluent plume travels Northward for 900 feet at an average width of 125 feet before it disperses.

Boca Raton Inlet

This inlet is shown in Figure 13 and is the connecting waterway between Lake Boca Raton and the Atlantic Ocean. The optical imagery recorded the plume from this inlet that flowed out into the ocean approximately 450 feet then turned to a Northwest direction curving toward shore. Approximately 1,100 feet north of the inlet the outflow plume touched the coast and could be traced another 1,400 feet along the coast before it dispersed. A relatively small portion of the outflow moved South from the inlet and flowed Southwest along the shore for 400 feet before it was dispersed.

Hillsborough Inlet

This inlet connects the Intercoastal Waterway with the Atlantic Ocean. Figure 14 shows the visible plume exiting the 310 foot wide mouth of the inlet and it has flowed in a Southeast direction for 1,200 feet. Here the plume turned Northward and was generally dispersed within 200 feet.

Pompano Beach Sewage Outfall

The terminus for this outfall is 7,400 feet from shore and at a depth of 90 feet. The effluent plume from the outfall was 30 feet wide

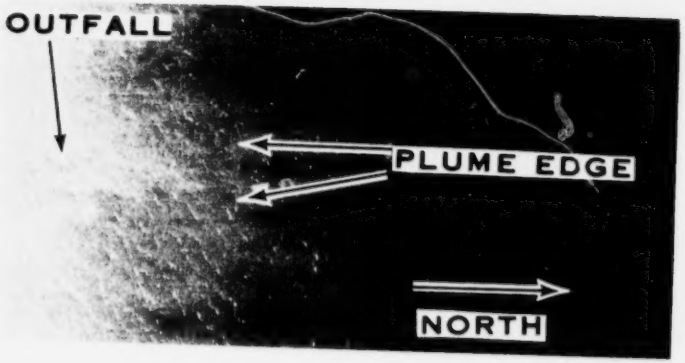


Figure 12 Boca Raton Sewage Outfall

Approximate scale 1:9,000

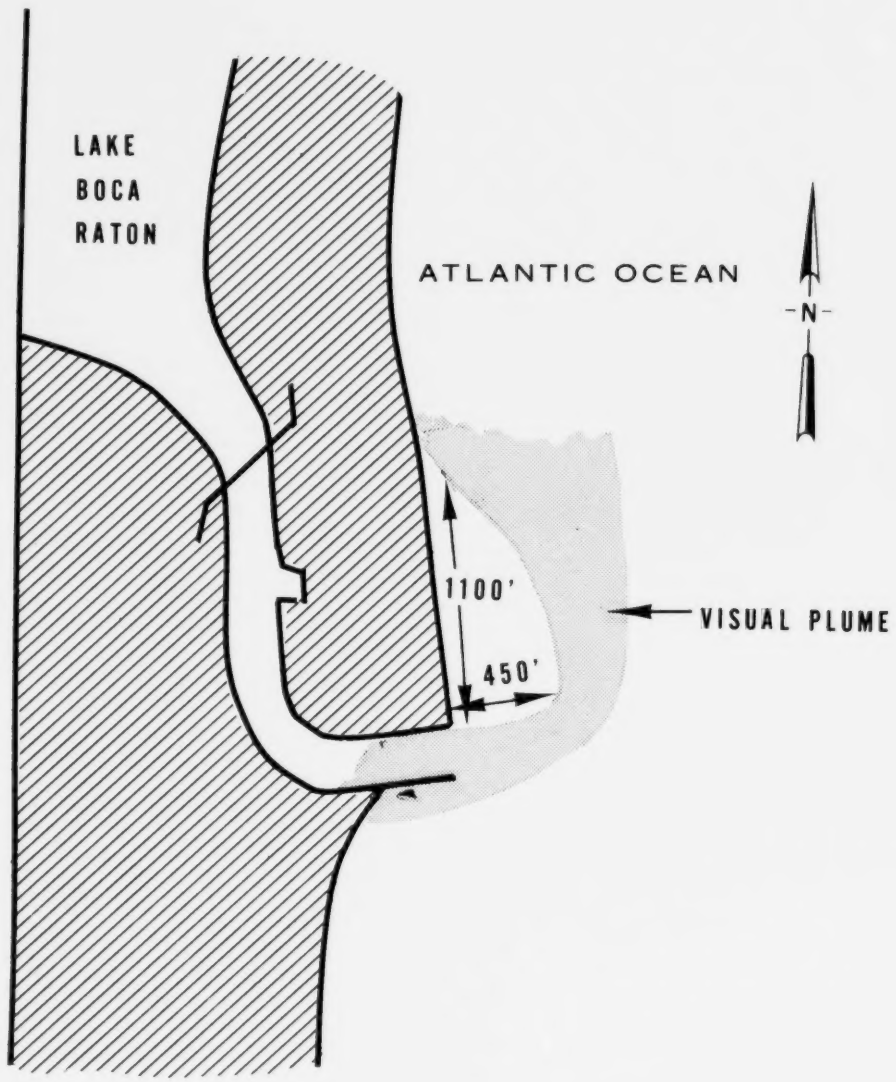


Figure 13 Boca Raton Inlet

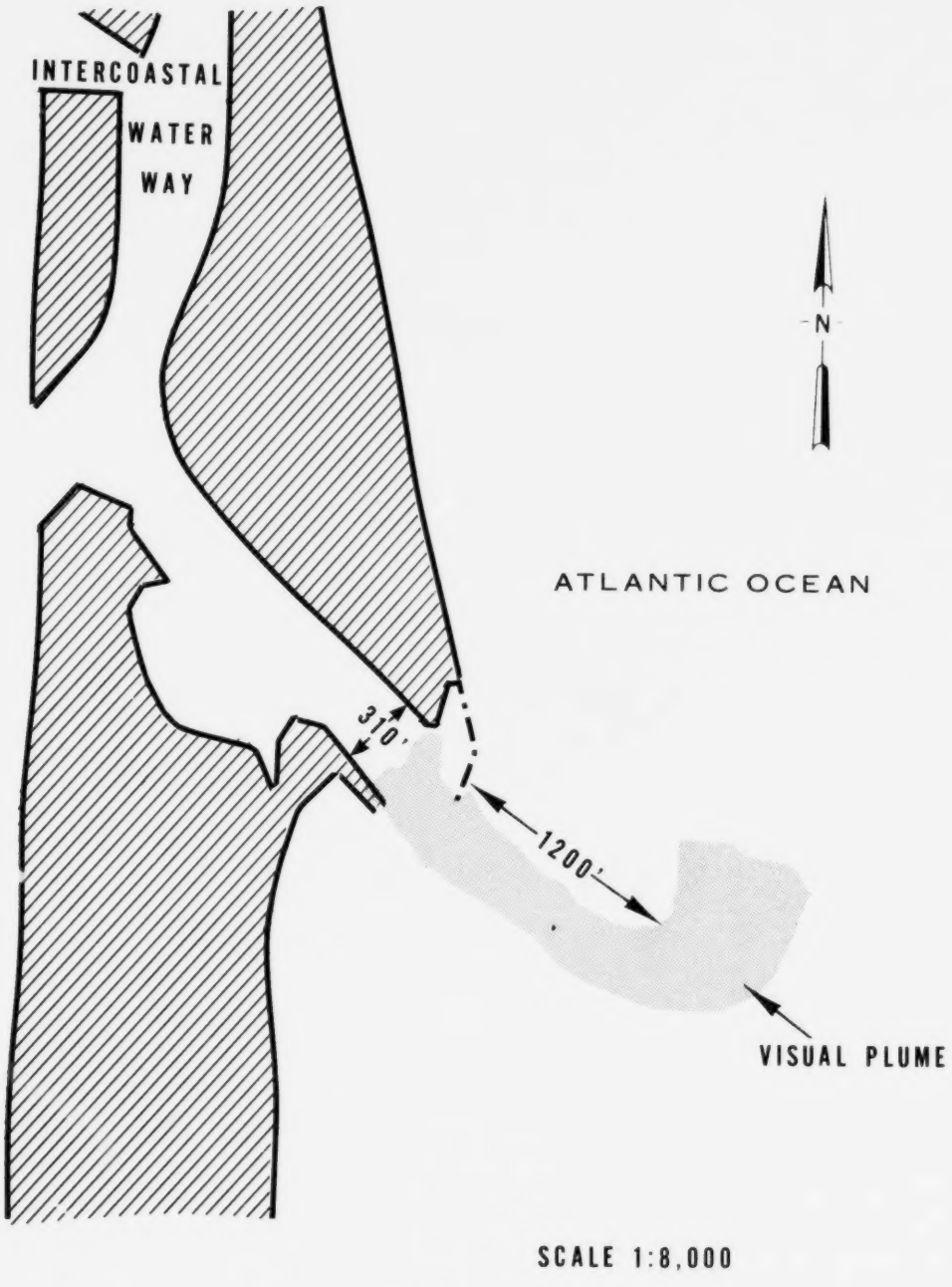


Figure 14 Hillsborrow Inlet

at its source and spread rapidly to 100 feet. It flowed Northward for 700 feet where, due to dispersion, the plume could no longer be seen. (Refer to Figure 15).

Port Everglades Inlet

This inlet which is 750 feet wide is the entrance to Port Everglades from the Atlantic Ocean. In Figure 16 the shape of the outflow plume from the inlet is shown. This plume extends 3,500 feet out into the Atlantic Ocean and 2,750 feet North from the mouth of the inlet. Also in Figure 16 is an area identified as "spoil area." It is in this area that refuse from channel dredging is deposited. In Figure 17, the dispersal zone of the spoil is quite evident, appearing very much like the patterns seen in river deltas.

Hollywood Sewage Outfall

The terminus for this outfall is 9,700 feet from shore and at a depth of 90 feet. Figure 18 shows the area where the effluent from the outfall reaches the ocean surface. The volume and force of this outflow is such that the ocean surface appears to be boiling. The core of the boil area is 23 feet in diameter and the overall disturbed area is 90 feet in diameter. The surface flow of the effluent spread rapidly, achieving a width of 650 feet in the first 700 feet as it traveled in a Northwest direction for a visible distance of 1,200 feet. The infrared imagery recorded the effluent from the outfall as being cooler than the ambient temperature of the ocean.

North Miami Beach Sewage Outfall

The terminus for this outfall is 10,000 feet from shore at a depth of 65 feet. In Figure 19 one may see the large plume created by the effluent from this outfall. At its source the plume was 300

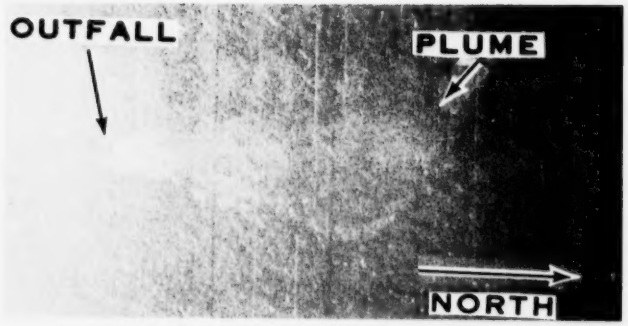


Figure 15 -Pompano Beach Sewage Outfall

Appraoximate scale 1:11,000

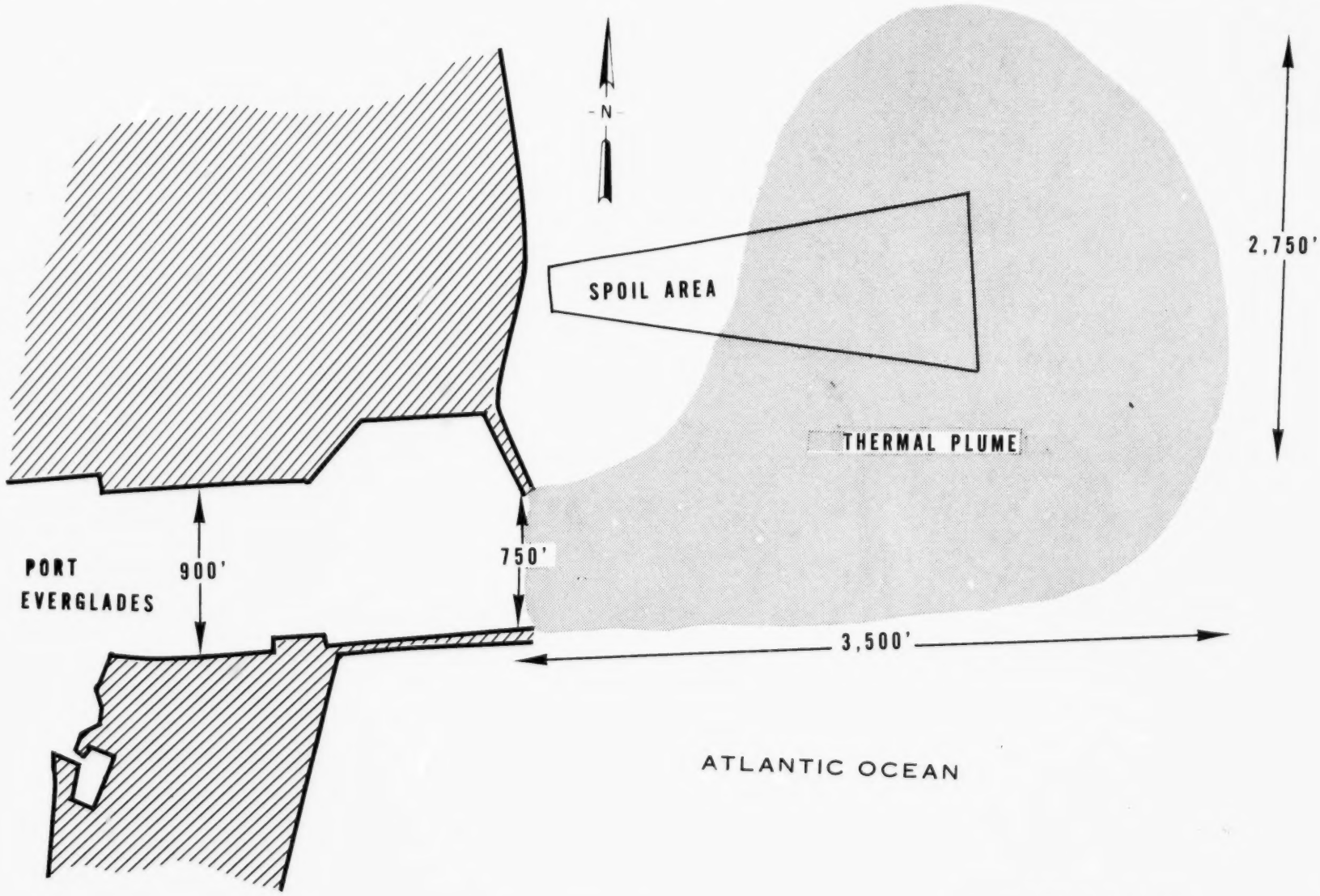


Figure 16 Port Everglades

Figure 17 - Port Everglades

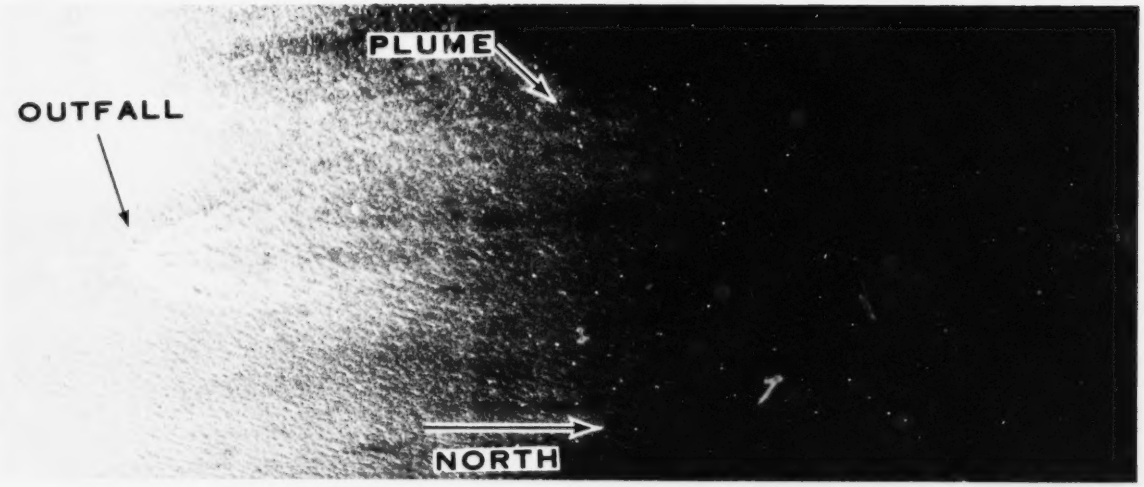
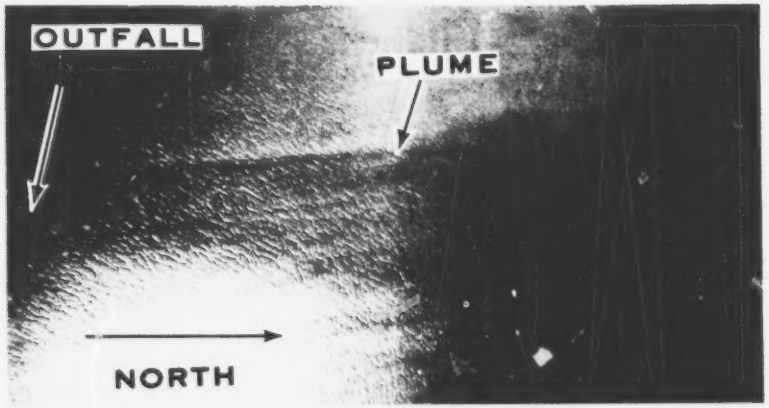


Figure 18 - Hollywood Sewage Outfall

Approximate scale 1:11,000



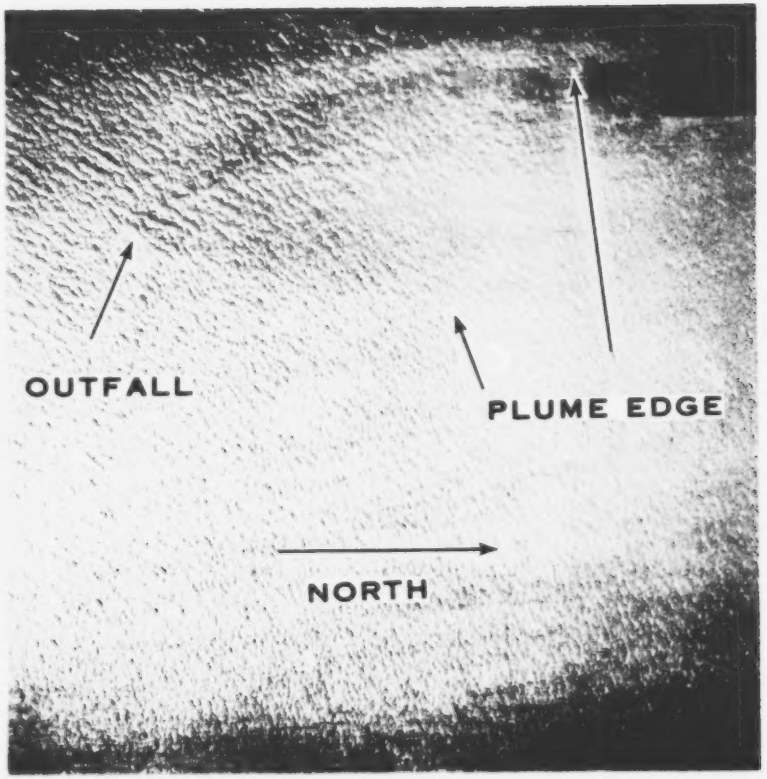


Figure 19 North Miami Beach Sewage Outfall

19A Approximate scale 1: 8,000
19B " " 1:18,000

feet wide and rapidly spread to an average width of 1,000 feet. The plume was visible for 9,000 feet as it traveled Northward parallel to shore.

Bakers Haulover Inlet

This inlet is the waterway connecting the Northern end of Biscayne Bay with the Atlantic Ocean. Figure 20 shows the shape of the warm plume as it traveled a distance of 4,500 feet from shore and 5,000 feet North from the inlet before it cooled to the ambient temperature of the ocean.

Miami Beach Sewage Outfall

The terminus for this outfall is 7,000 feet from shore at a depth of 140 feet. Figure 21 shows this outfall's effluent plume which at the start was 200 feet wide, and spread rapidly to 600 feet as it flowed Northward. The contents of the plume had dispersed to such a degree that it was no longer visible 6,800 feet from its source.

Miami Sewage Outfall

The terminus for this outfall is 4,600 feet from shore but only at a depth of 18 feet. The discharge from this outfall, like that of the Hollywood outfall, appeared to be boiling as it reached the surface of the ocean. The boil area was oval in shape, being 270 feet long in the North-South direction and 175 feet wide in the East-West direction. The infrared imagery showed a large, warm plume generated from the effluent of this outfall. In the area of the "boil" the thermal plume was 1,000 feet wide. The plume moved to

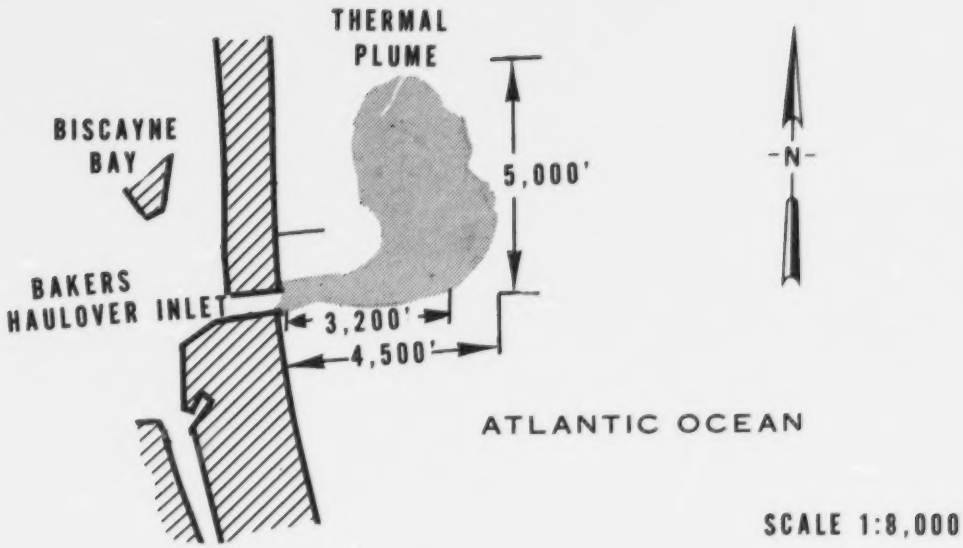


Figure 20 Bakers Haulover Inlet

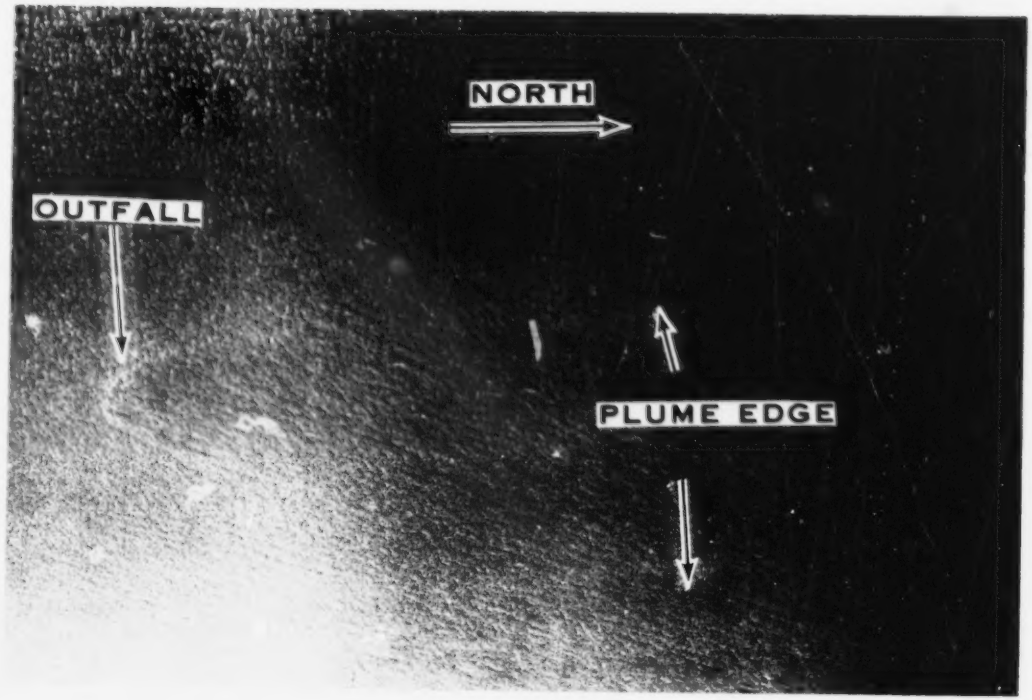


Figure 21 Miami Beach Sewage Outfall
Approximate scale 1:11,000

the North and, at a distance of 5,000 feet from the source, was 3,500 feet wide. The cool outflow from the Government Cut dissipated this thermal plume (Figures 22 and 23). The Government Cut is the connecting waterway between the Atlantic Ocean and the Miami Harbor in Biscayne Bay.

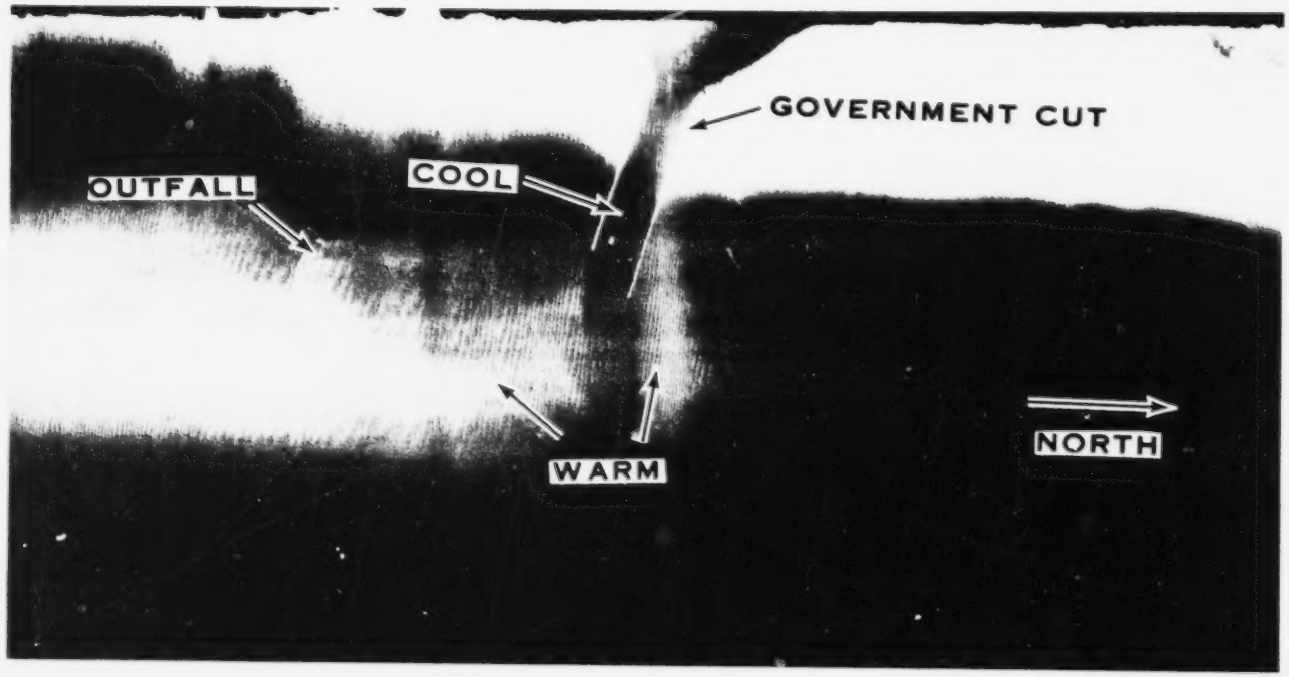


Figure 22 Miami Sewage Outfall
Approximate Scale 1:41,700

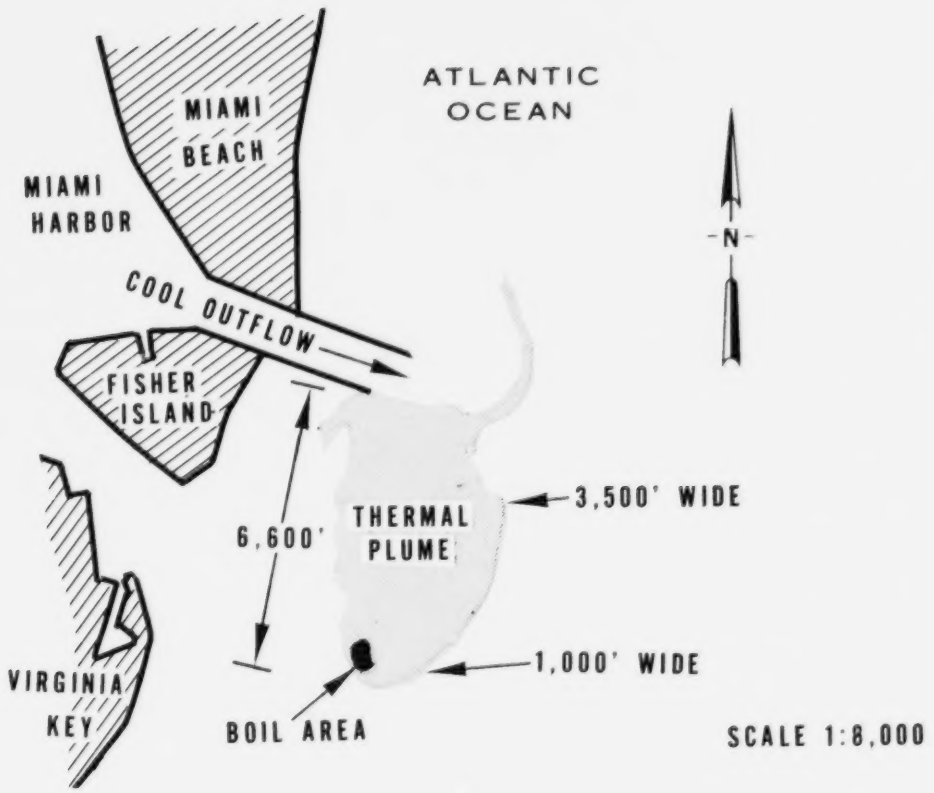


Figure 23 Miami Outfall Thermal Plume

Mapping of the Ocean Bottom

Definite features, such as coral reefs, sand, mud, rock, and aquatic growth on the bottom strata, could not be identified in the imagery. There were fairly well defined light/dark-toned areas seen in the imagery, but they could not be classified except as cosmetic features of the ocean bottom. These different toned areas are shown in Figure 24A through 24H, with the hatched markings depicting the dark tones. (An example of cosmetic features is shown in Figure 17).

A

AT

N
WEST PALM BEACH
FLAGLER MEMORIAL BRIDGE
26°42'30''
ROYAL PALM BRIDGE
PALM BEACH

ATLANTIC OCEAN

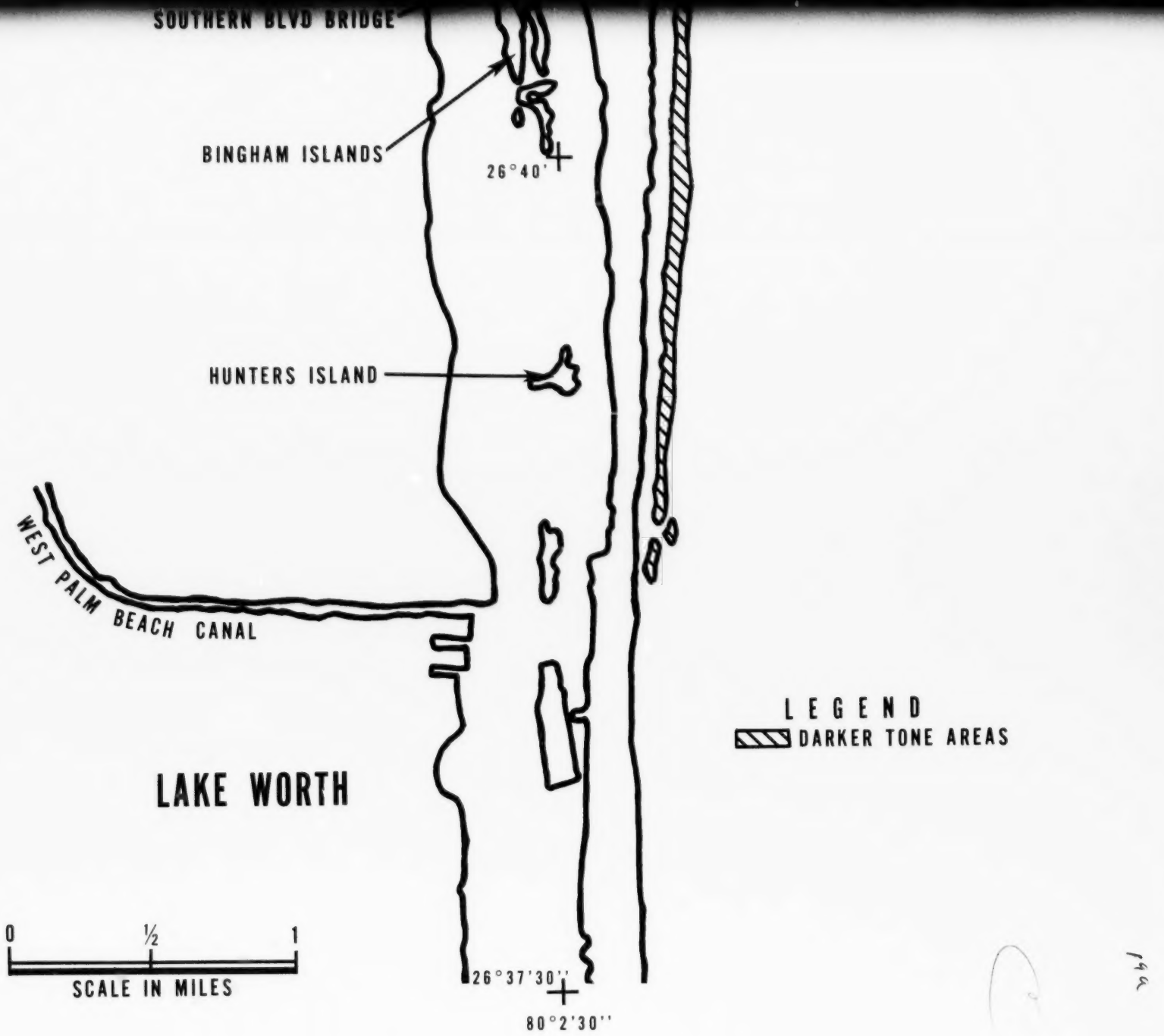
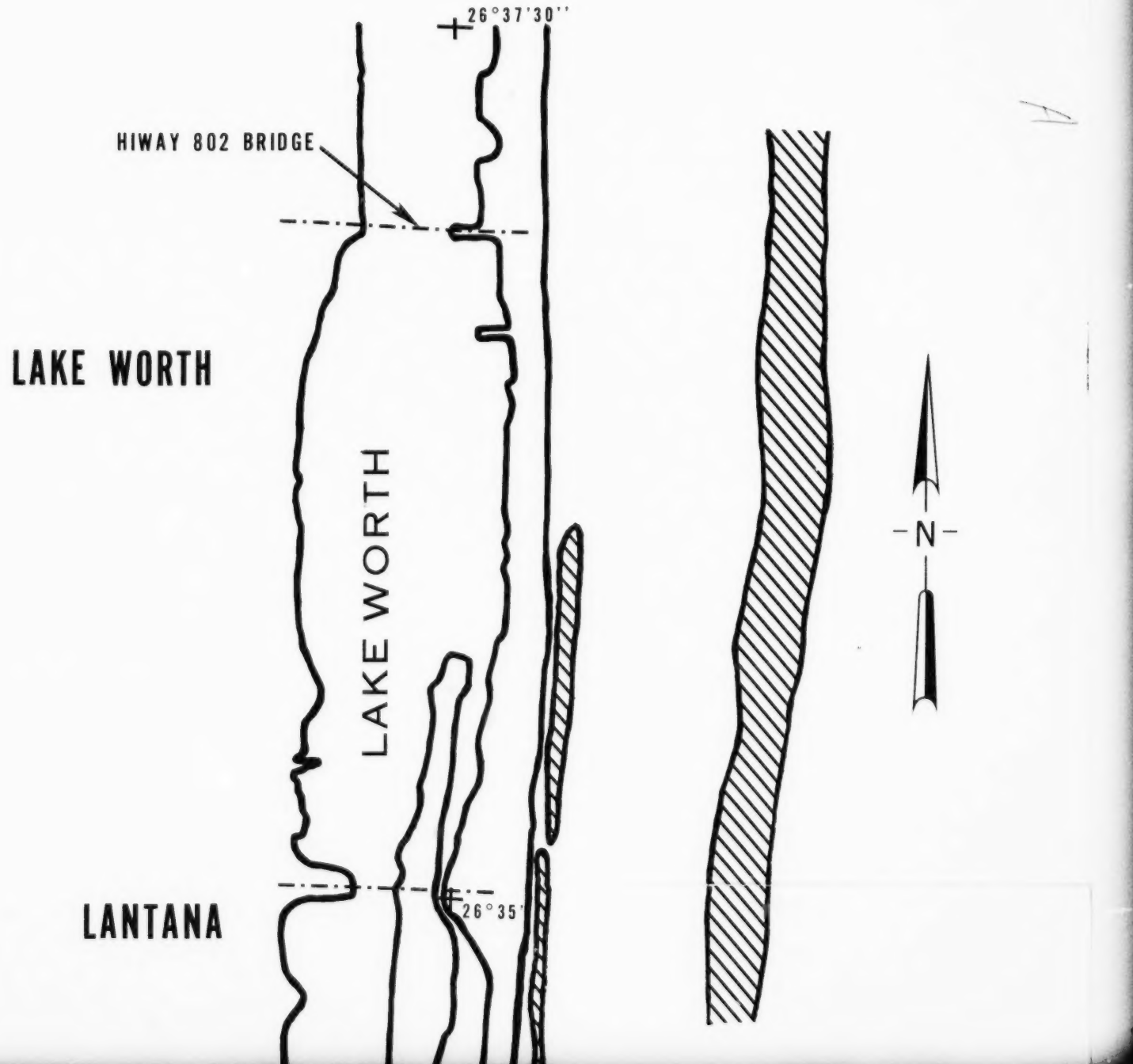


Figure 24-A. Darker Tone Areas on the Ocean Bottom


26°37'30"
HIWAY 802 BRIDGE
LAKE WORTH
LAKE WORTH
LANTANA
26°35'
N

B

ATLANTIC OCEAN

SOUTH LAKE WORTH INLET

26°32'30''

26°35'

LAKE

LANTANA

HYPOLUXO ISLAND

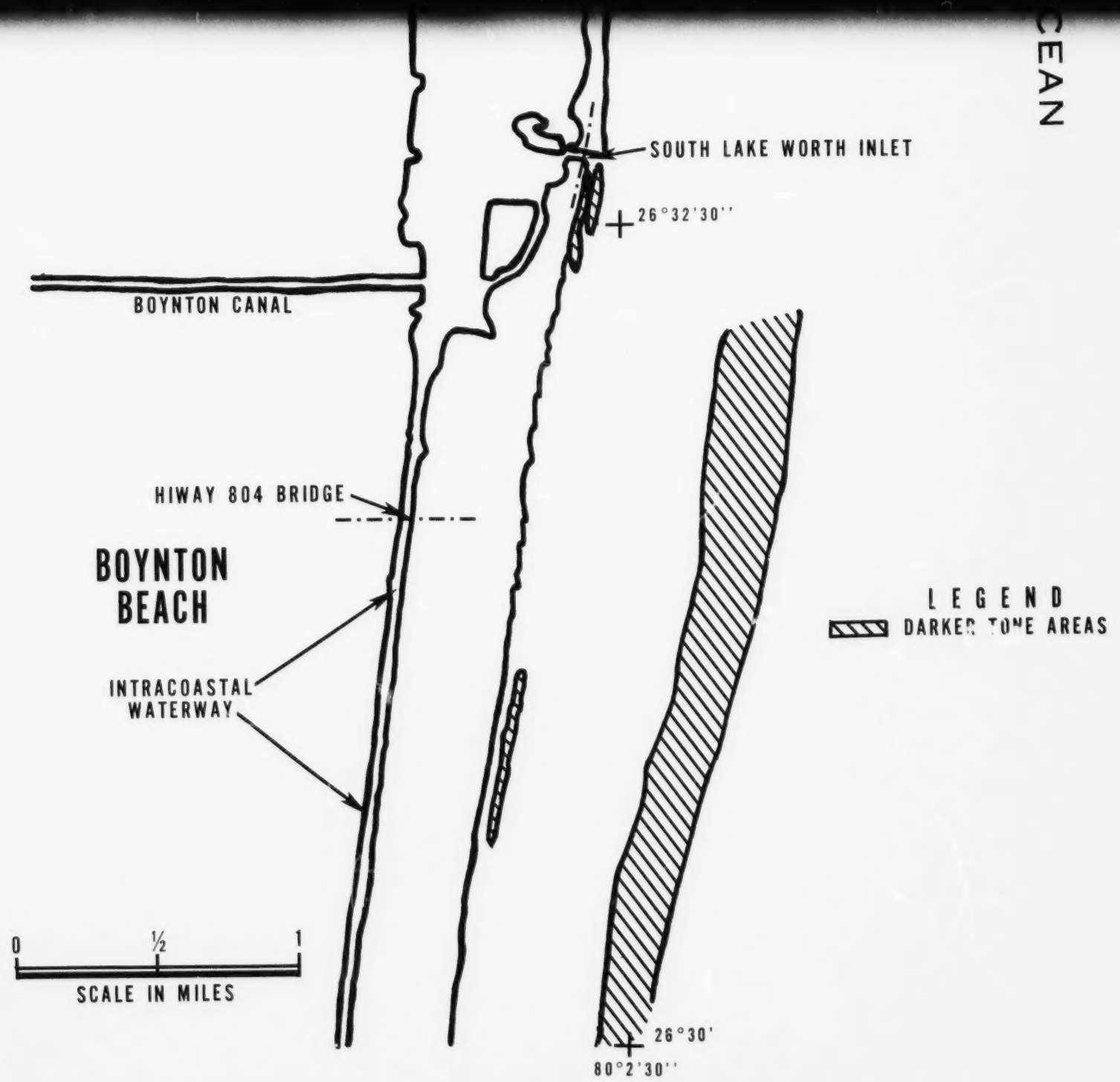
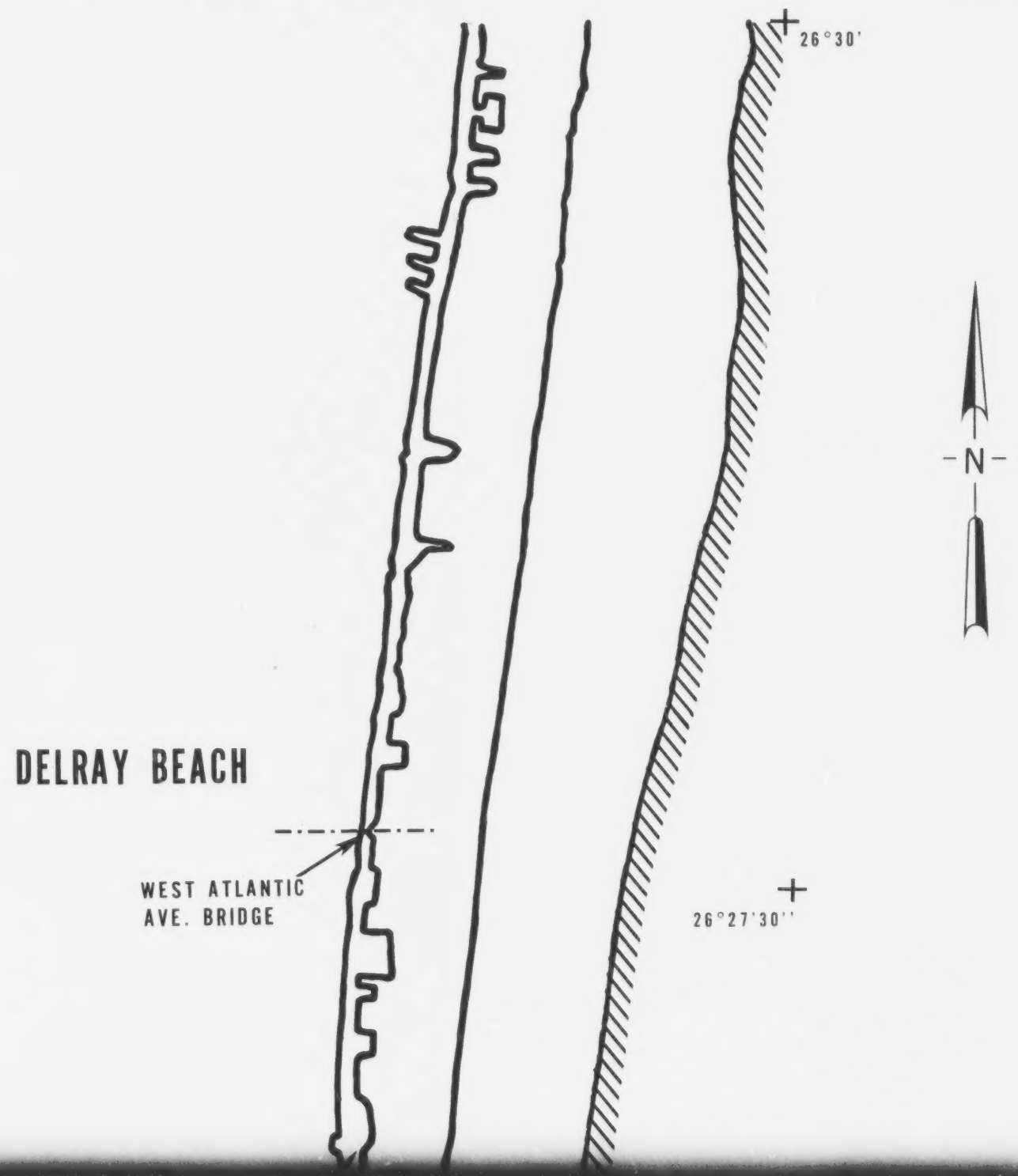


Figure 24-B. Darker Tone Areas on the Ocean Bottom


26°30'
N
DELRAY BEACH
WEST ATLANTIC
AVE. BRIDGE
26°27'30''

B

ATLANTIC OCEAN

26°27'30''

26°25'

DELRAY BEACH

WEST ATLANTIC AVE. BRIDGE

INTRACOASTAL WATERWAY

TROPIC ISLE HARBOR

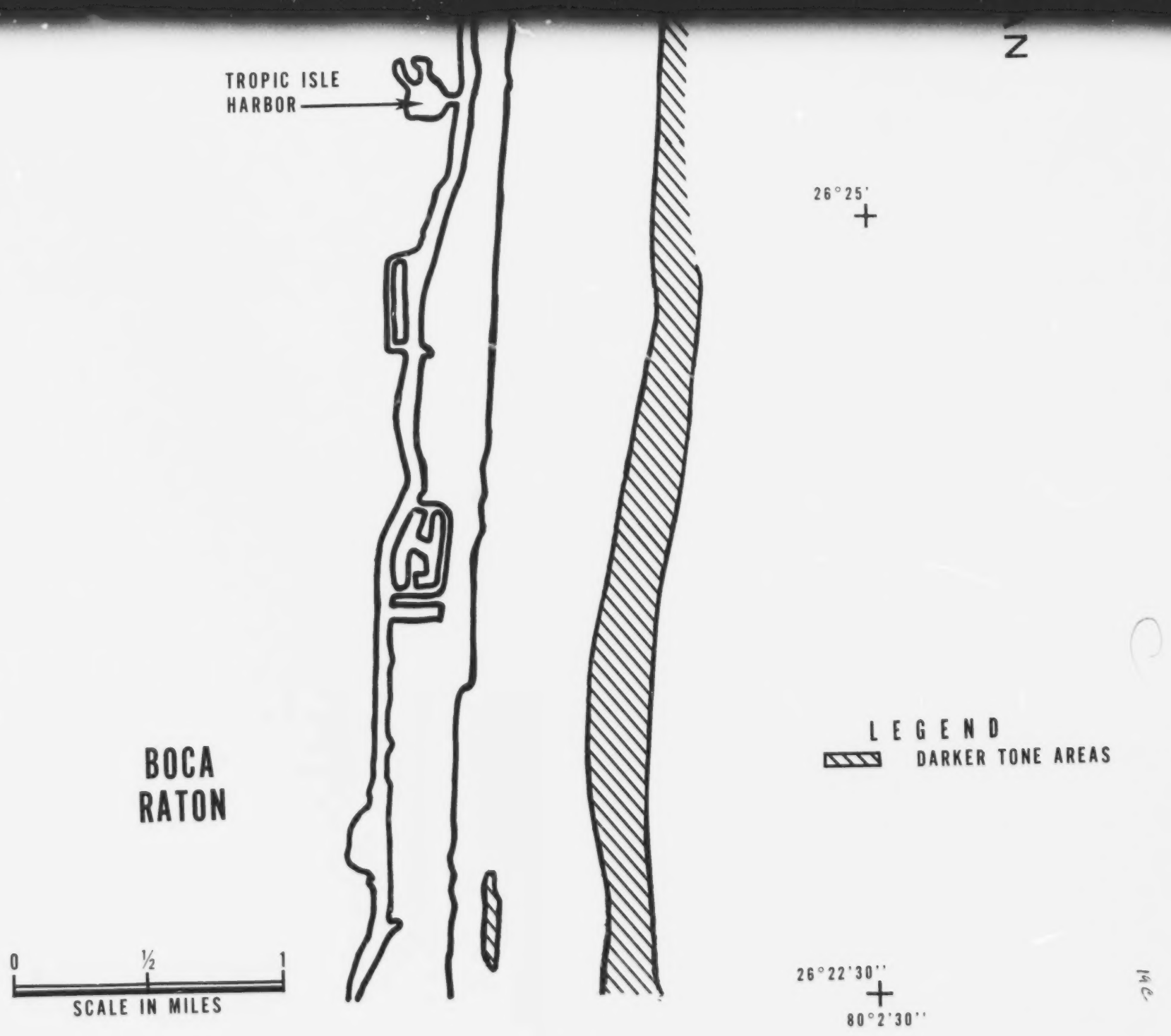
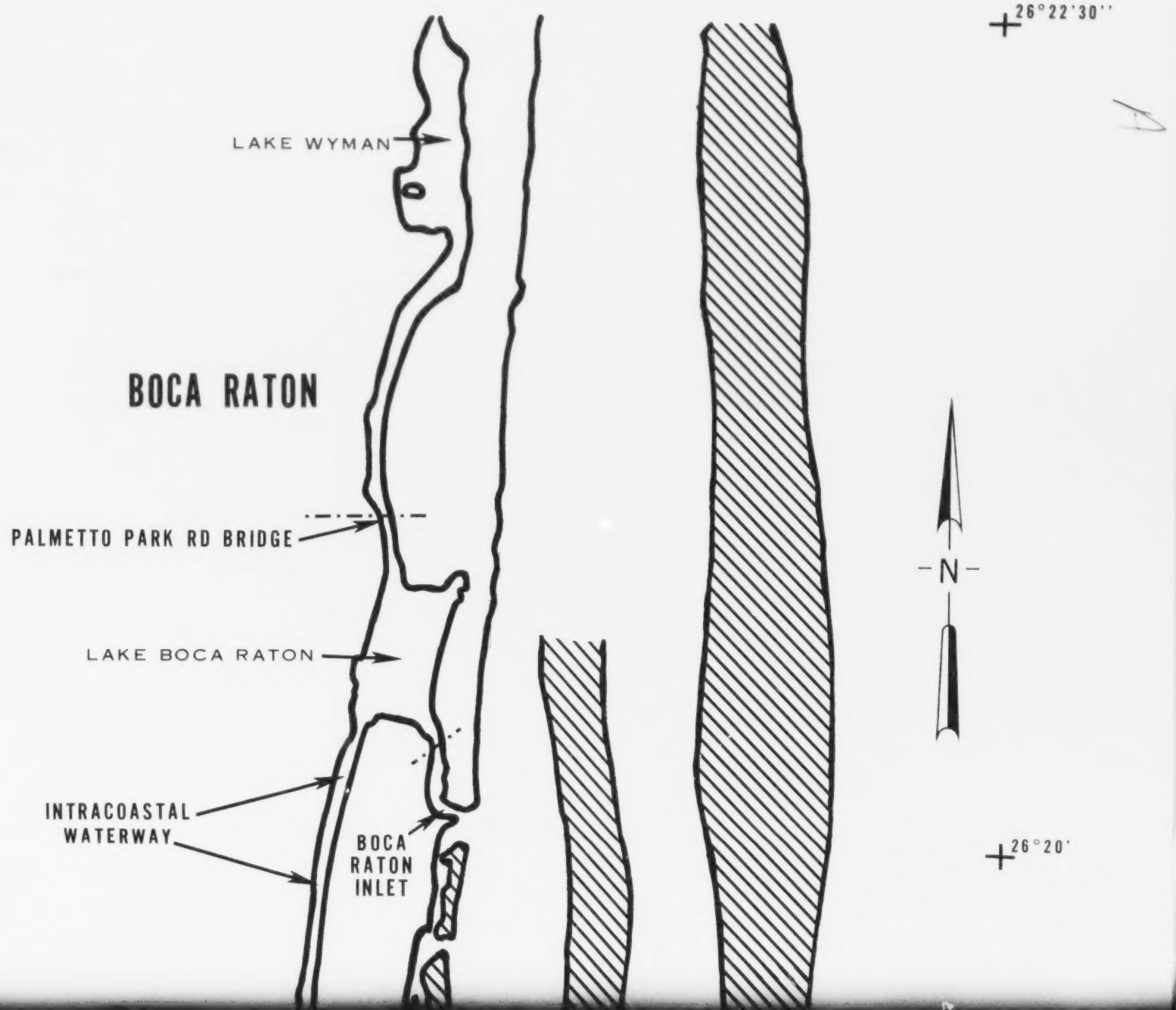
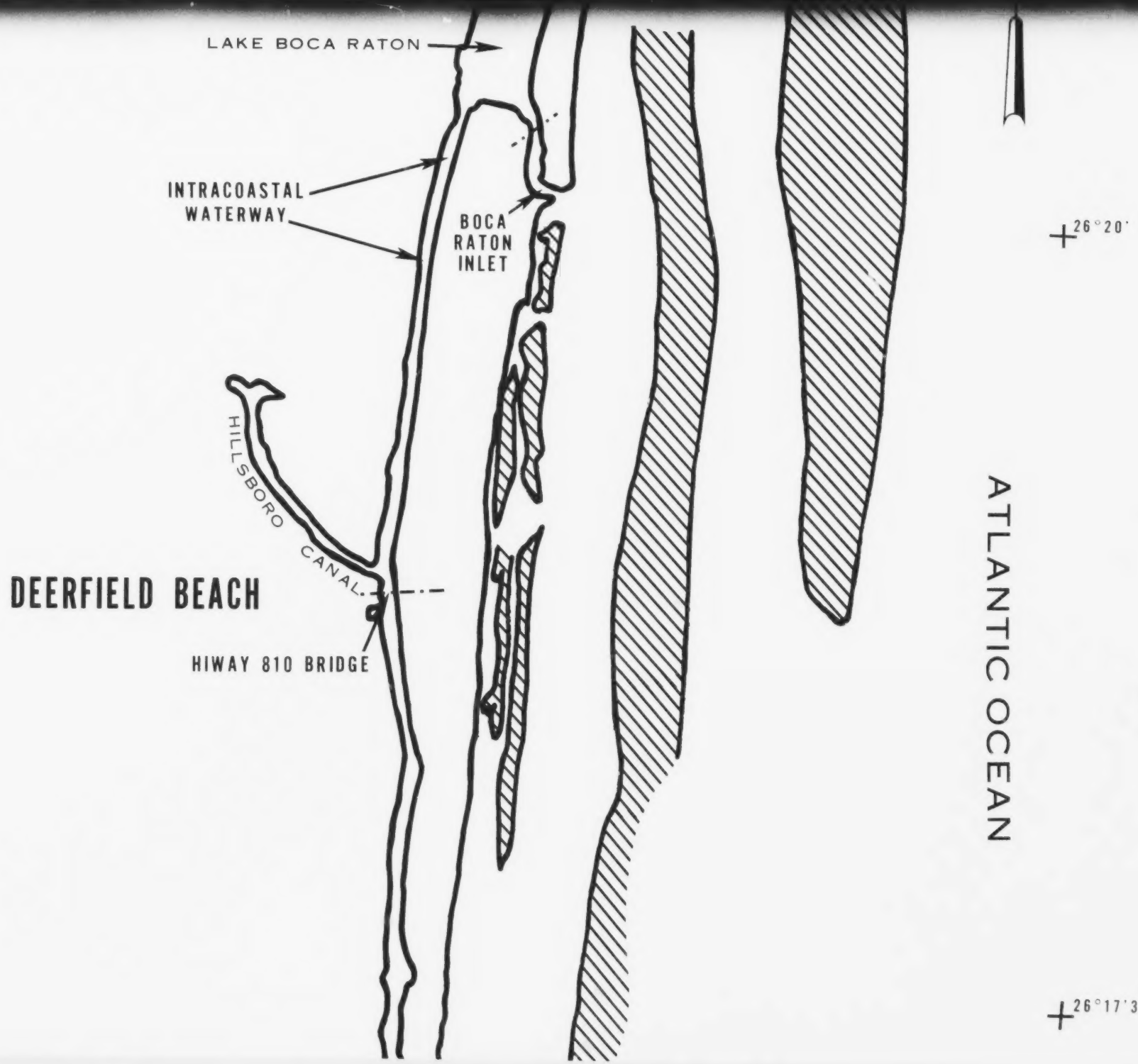


Figure 24-C. Darker Tone Areas on the Ocean Bottom


26°22'30''
LAKE WYMAN
BOCA RATON
PALMETTO PARK RD BRIDGE
LAKE BOCA RATON
INTRACOASTAL WATERWAY
BOCA RATON INLET
N
26°20'


LAKE BOCA RATON
INTRACOASTAL WATERWAY
BOCA RATON INLET
HILLSBORO CANAL
DEERFIELD BEACH
HIWAY 810 BRIDGE
ATLANTIC OCEAN
26°20'
26°17'30"

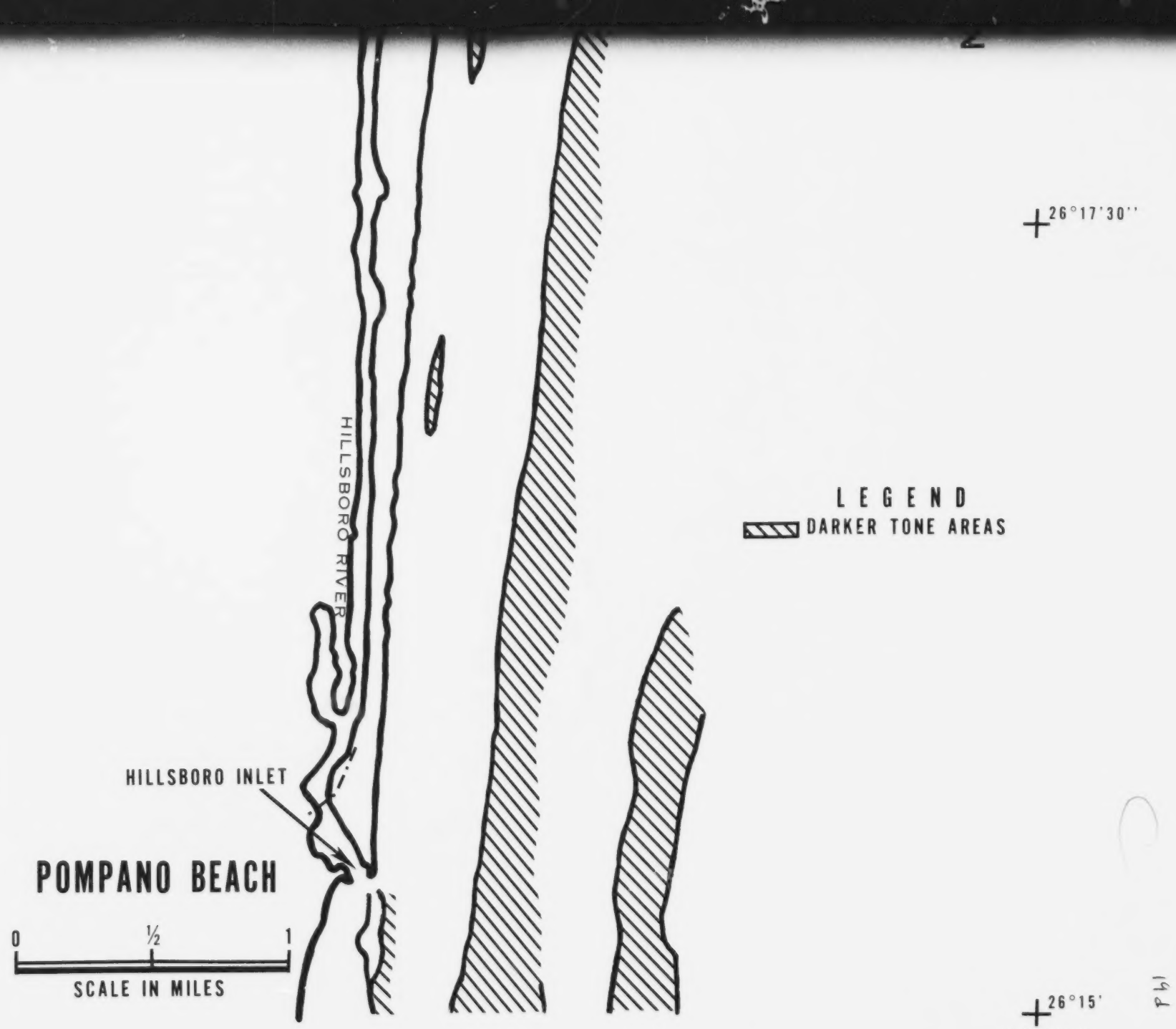
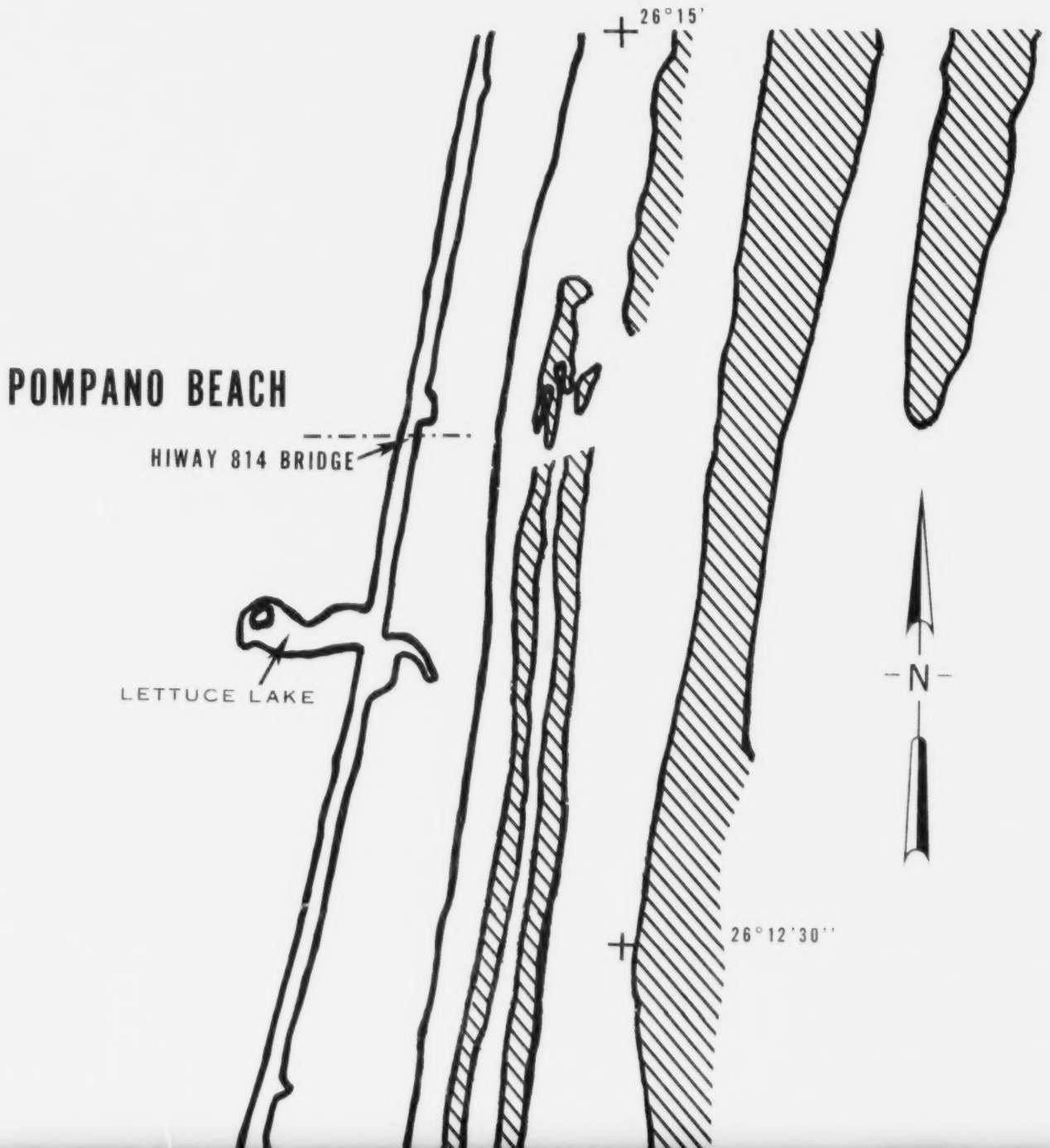


Figure 24-D. Darker Tone Areas on the Ocean Bottom


26°15'
POMPANO BEACH
HIWAY 814 BRIDGE
LETTUCE LAKE
N
26°12'30''

ATLANTIC OCEAN
26° 12' 30''
26° 10'
INTRACOASTAL
WATERWAY
FORT LAUDERDALE

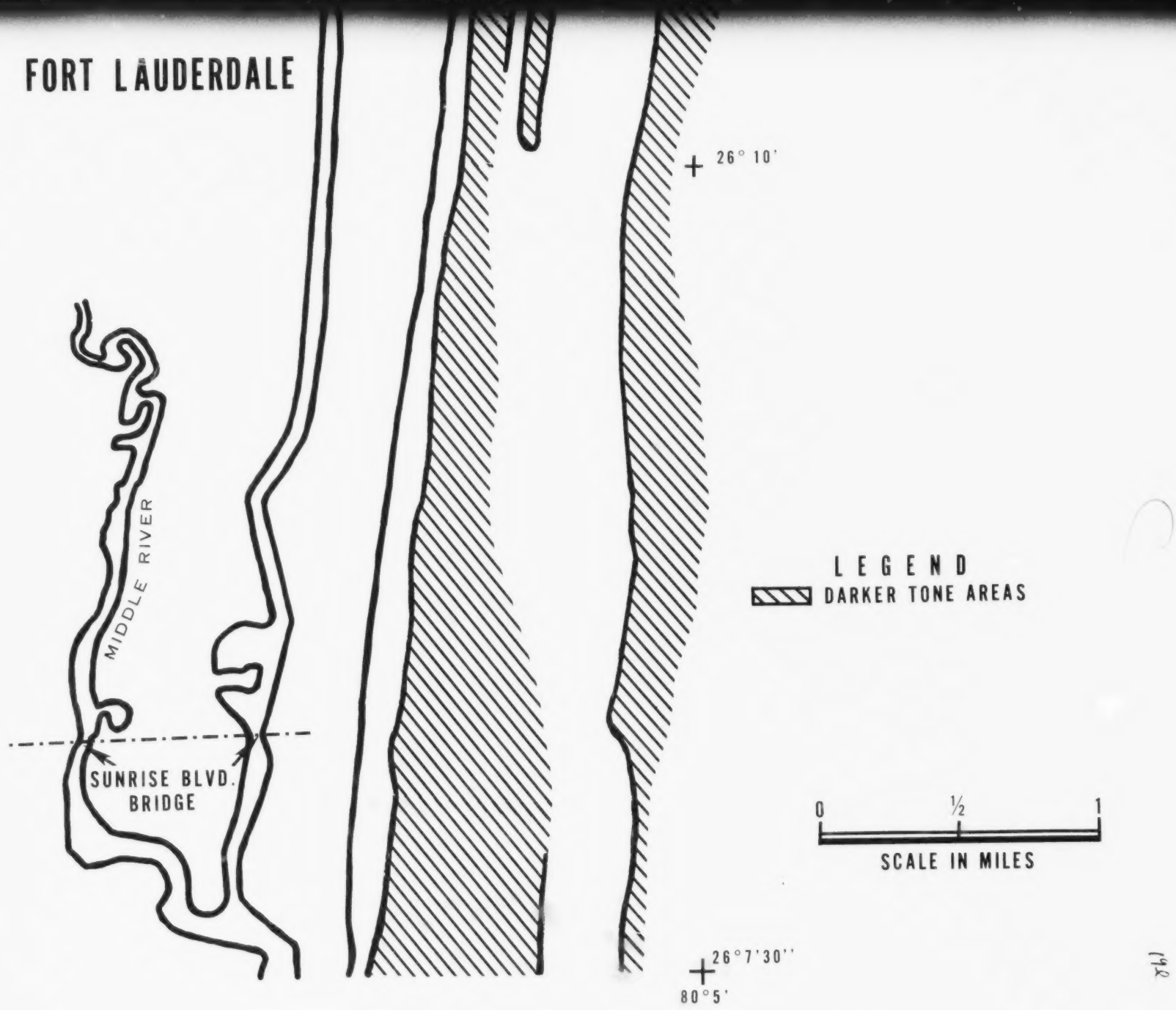
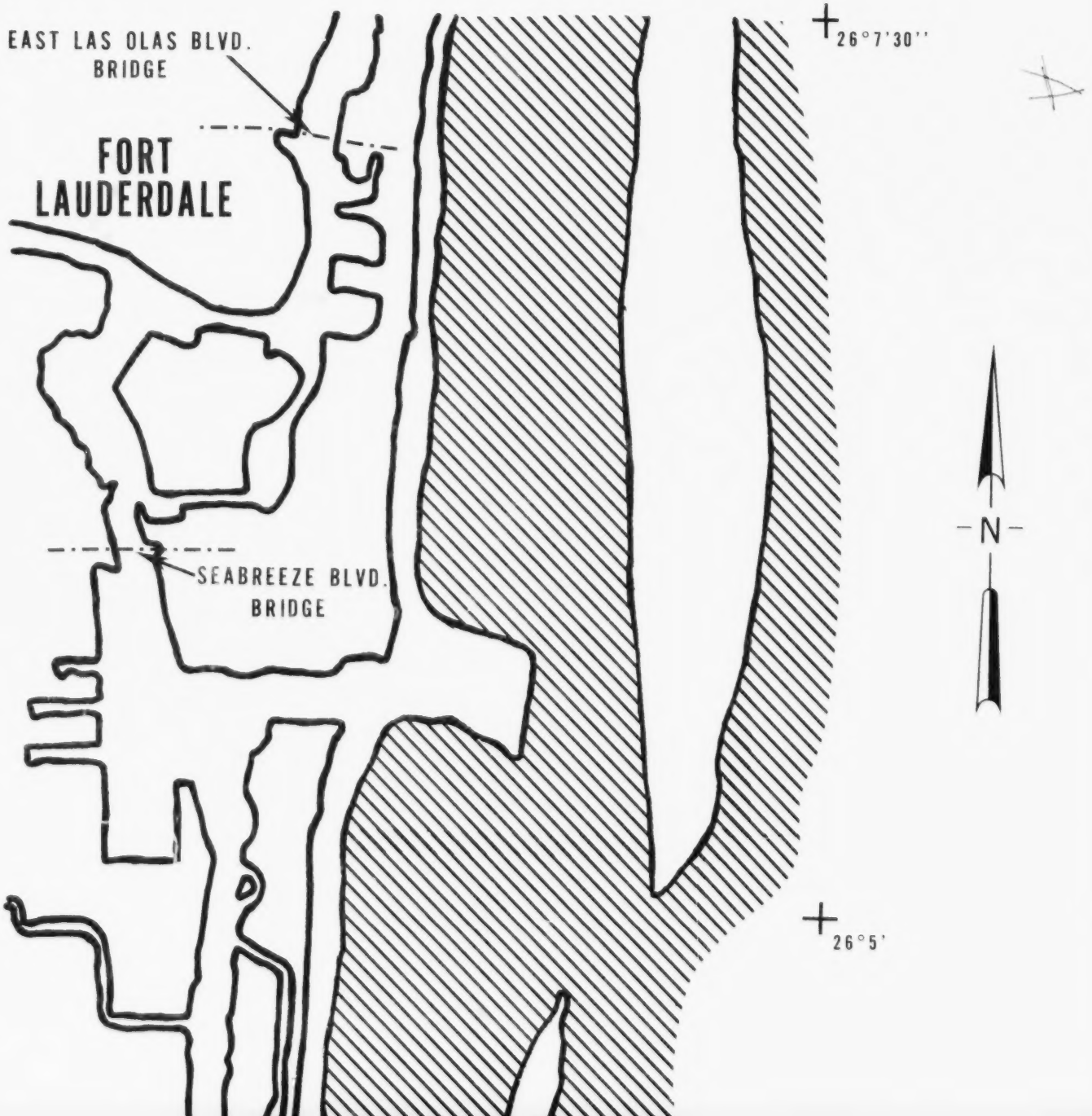
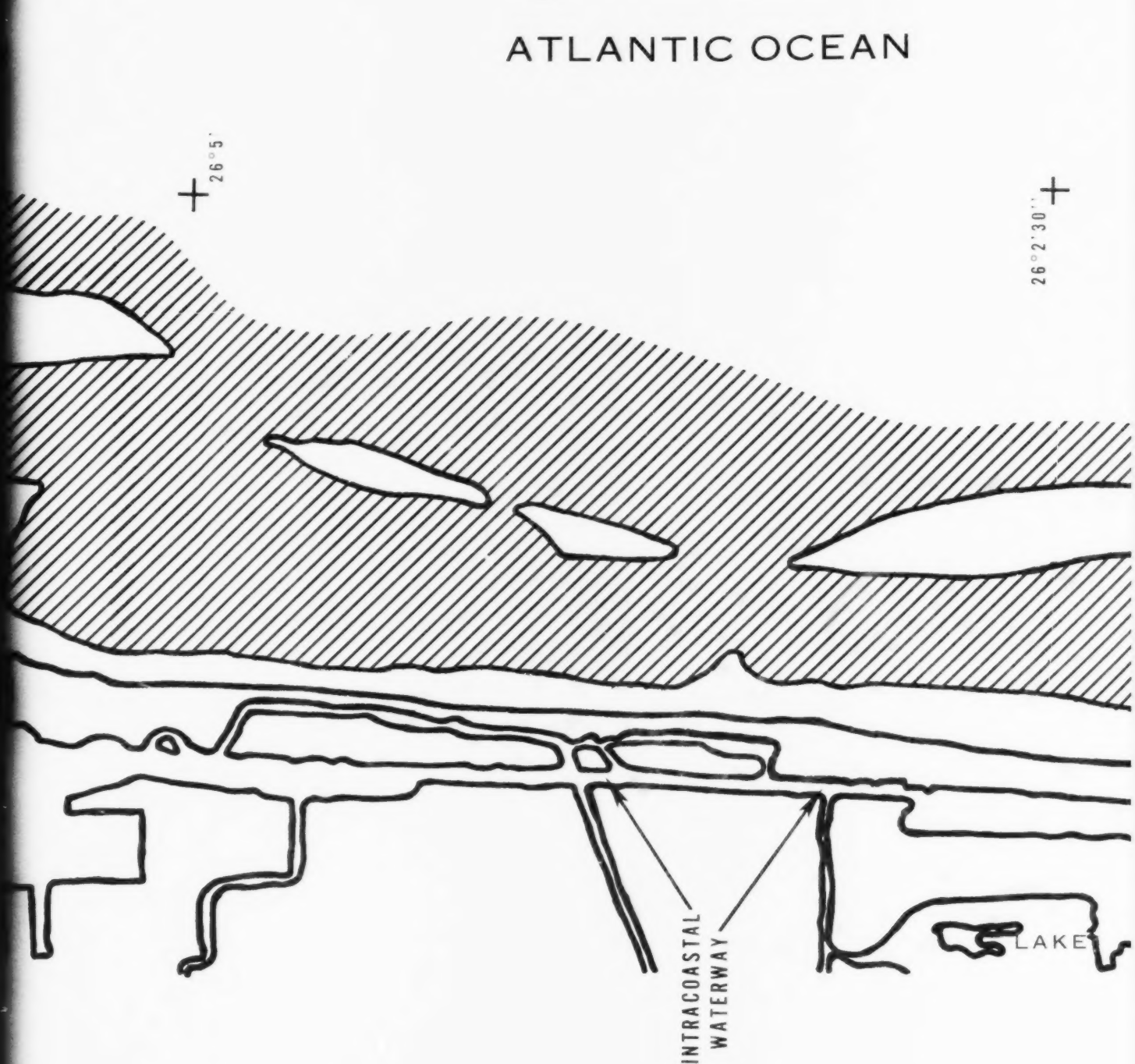


Figure 24-E. Darker Tone Areas on the Ocean Bottom


EAST LAS OLAS BLVD.
BRIDGE
FORT
LAUDERDALE
SEABREEZE BLVD.
BRIDGE
26°7'30"
26°5'
N


ATLANTIC OCEAN
26°5'
26°2'30"
INTRACOASTAL
WATERWAY
LAKE

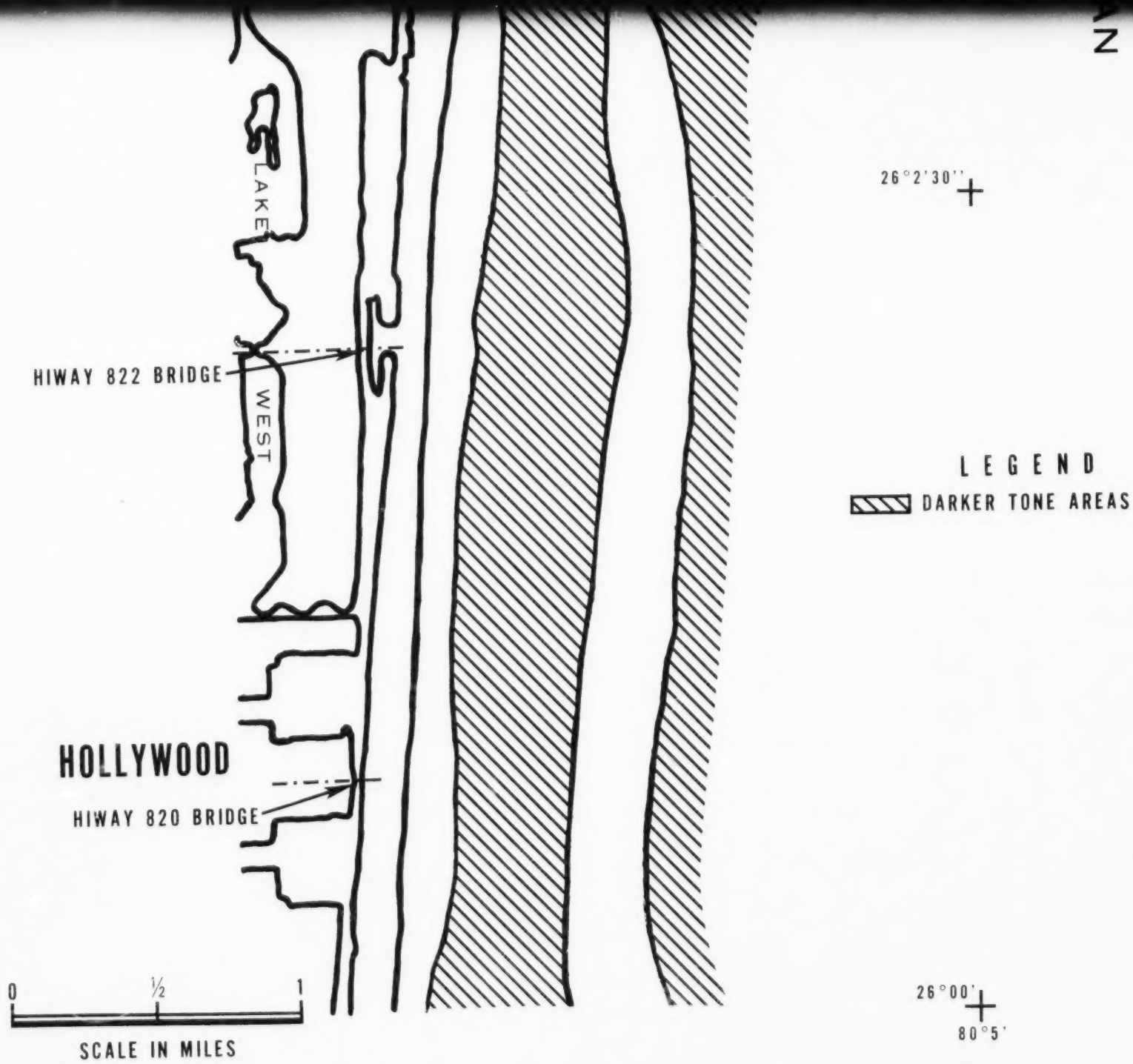
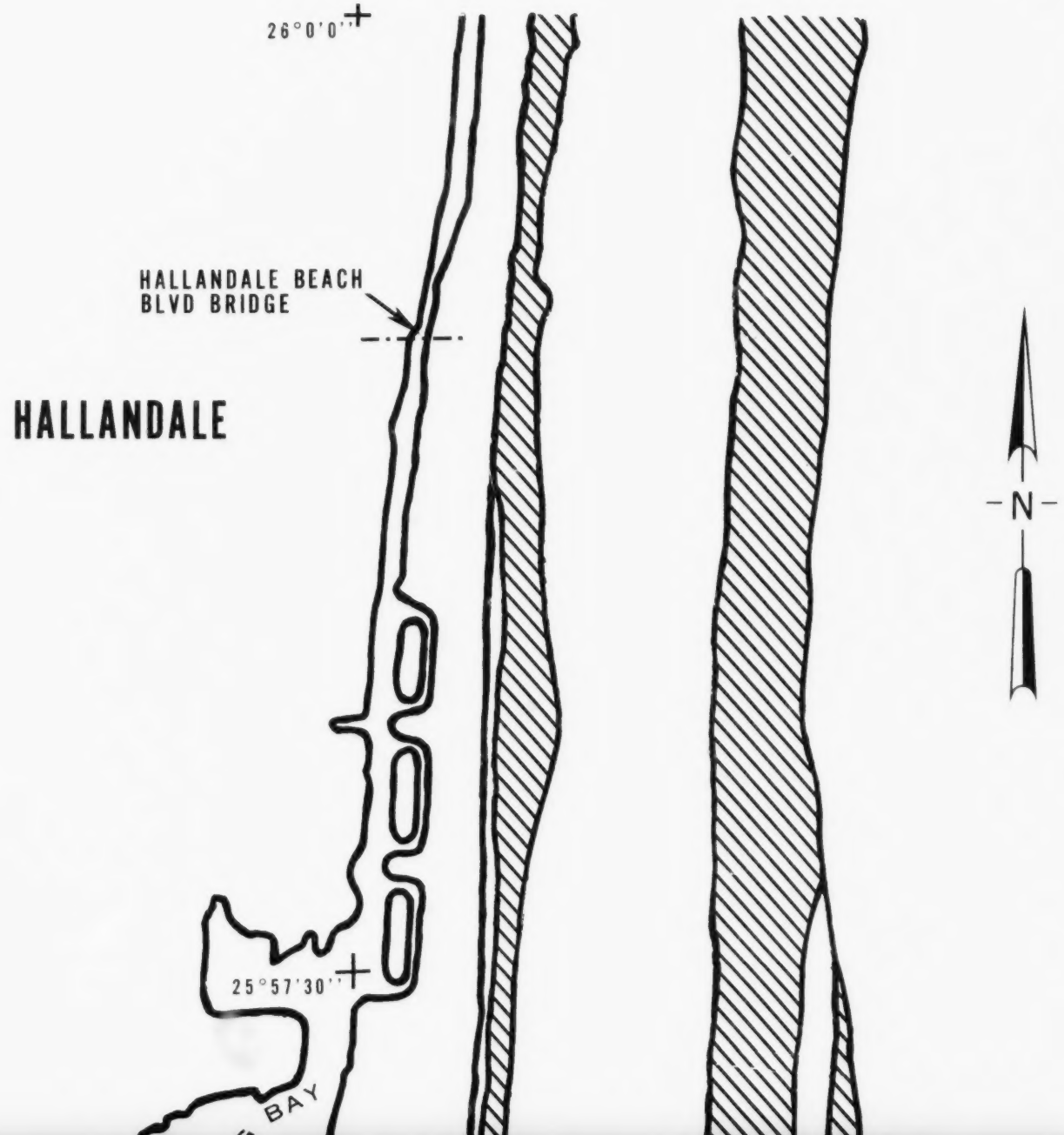
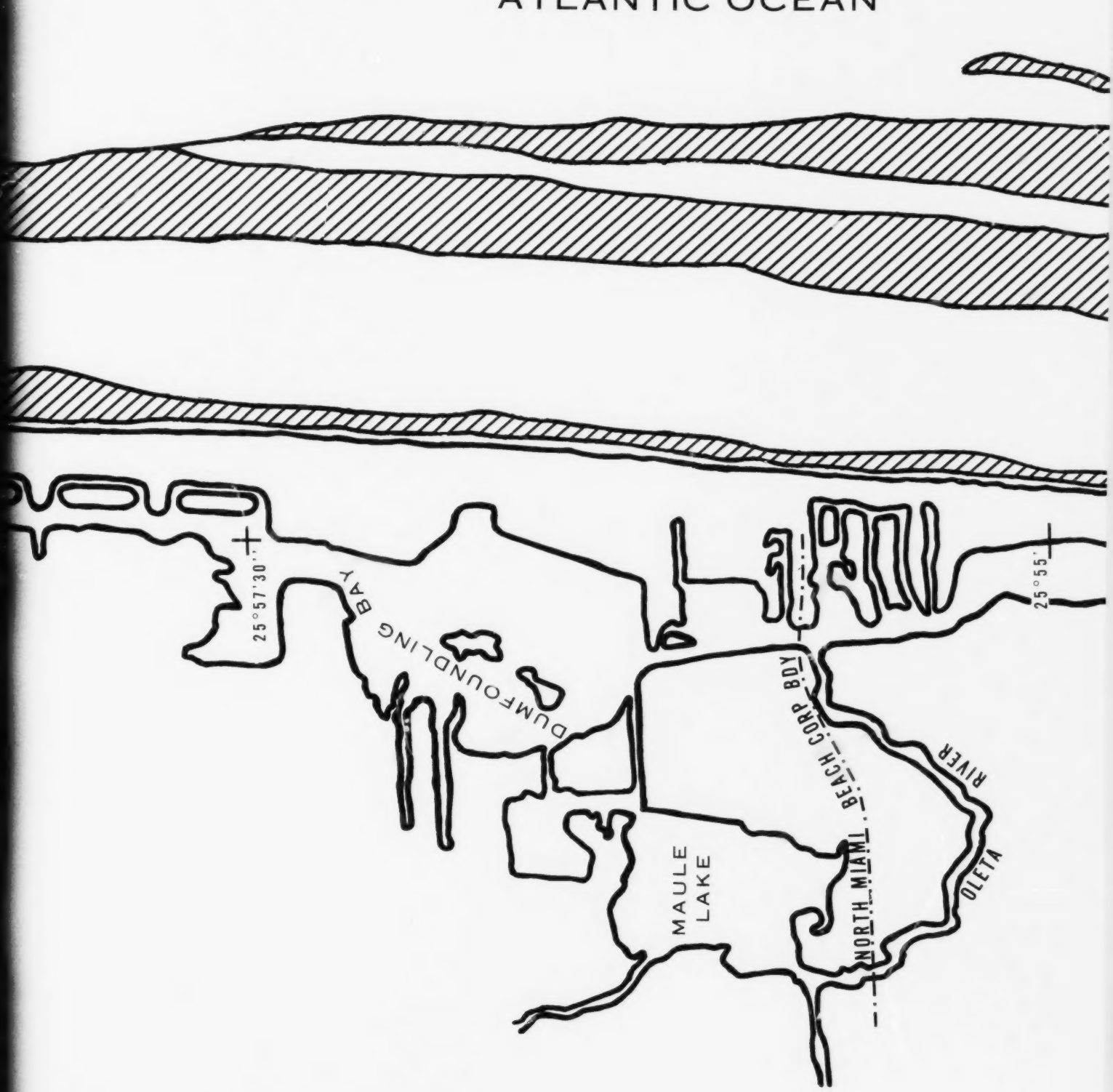


Figure 24-F. Darker Tone Areas on the Ocean Bottom


26°0'0"
HALLANDALE BEACH
BLVD BRIDGE
HALLANDALE
N
25°57'30"
BAY


ATLANTIC OCEAN
25°57'30"
BAY
DUMFOUNDLING
MAULE
LAKE
NORTH MIAMI BEACH CORP BDY
25°55'
RIVER
OLETA

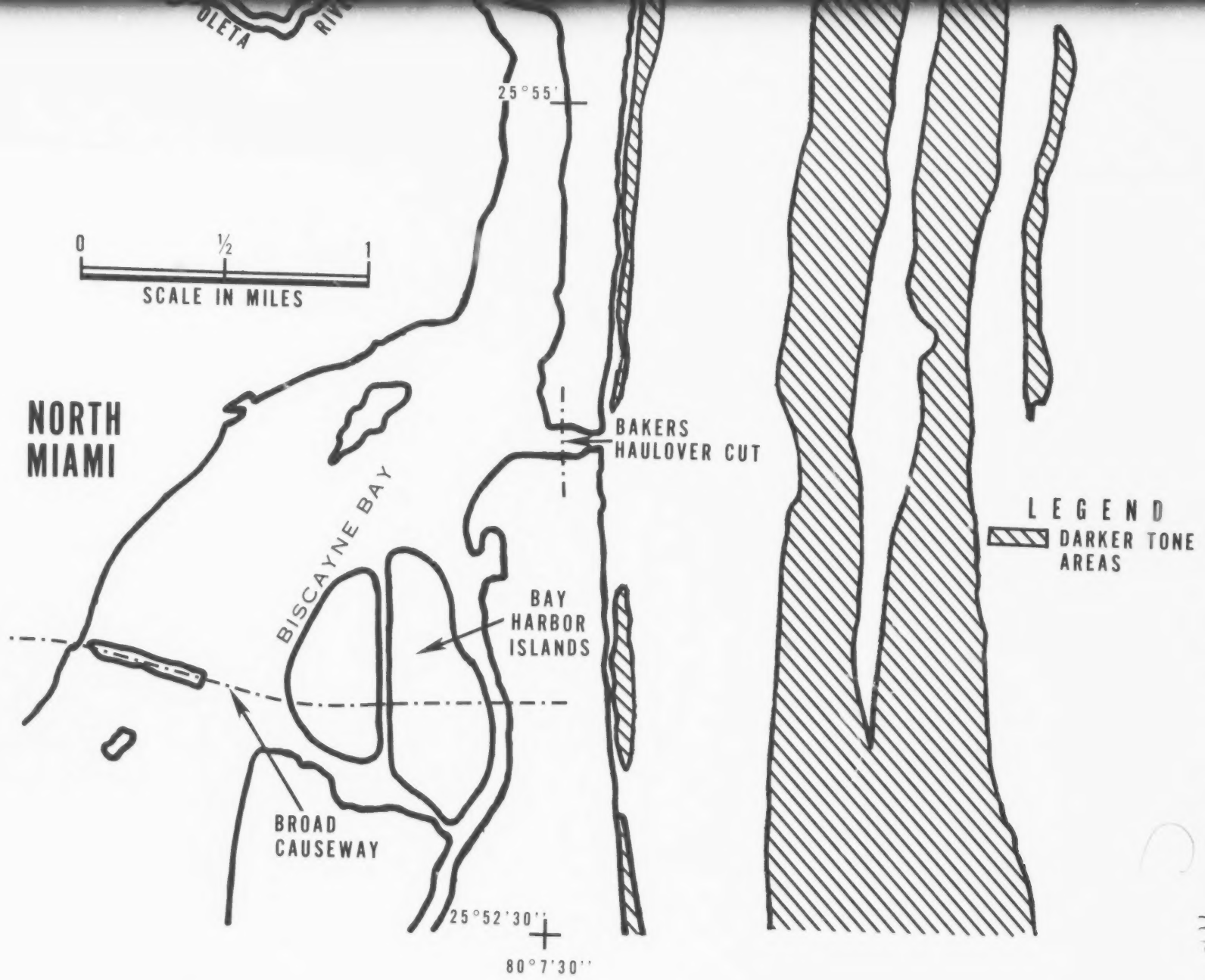
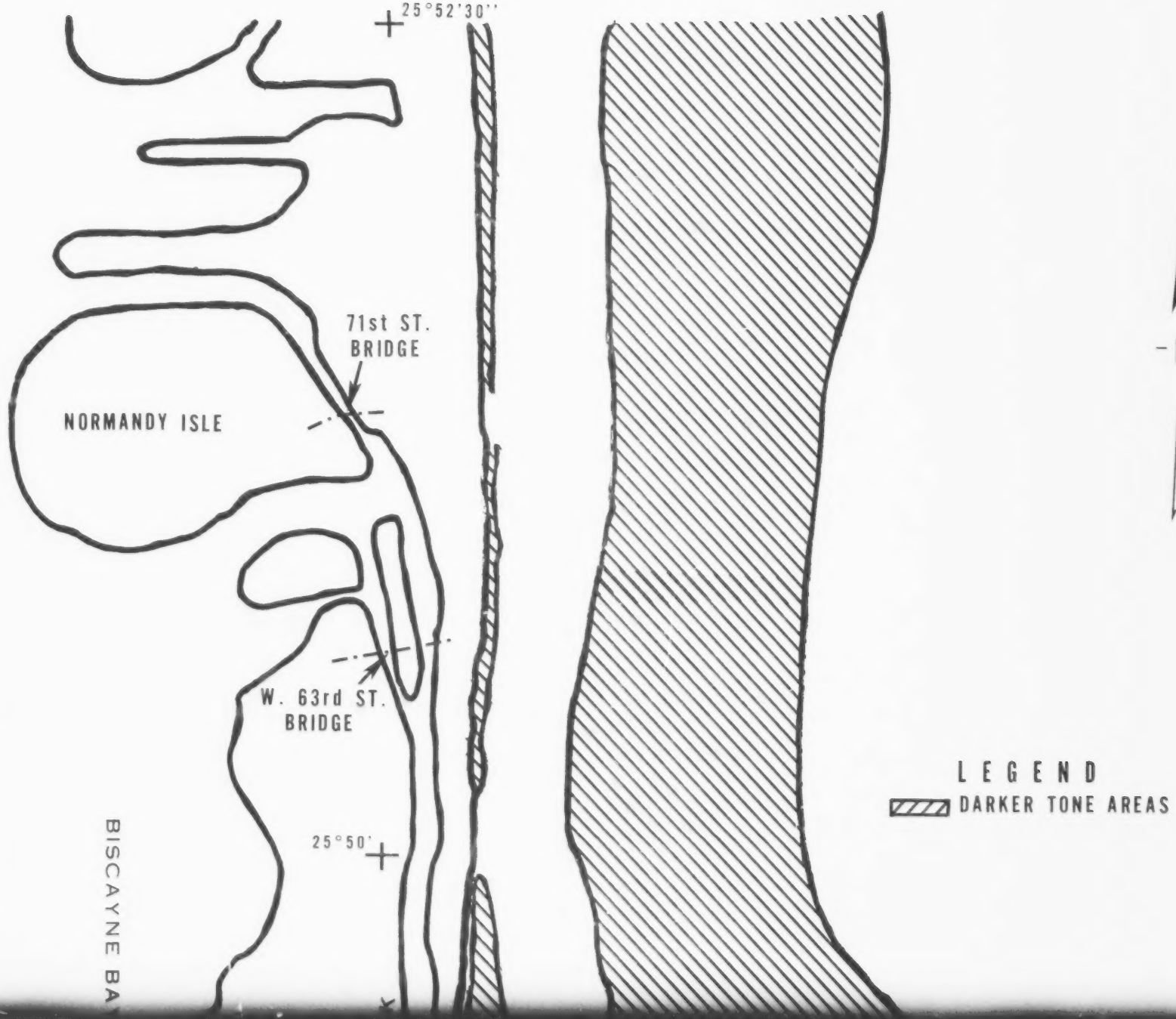
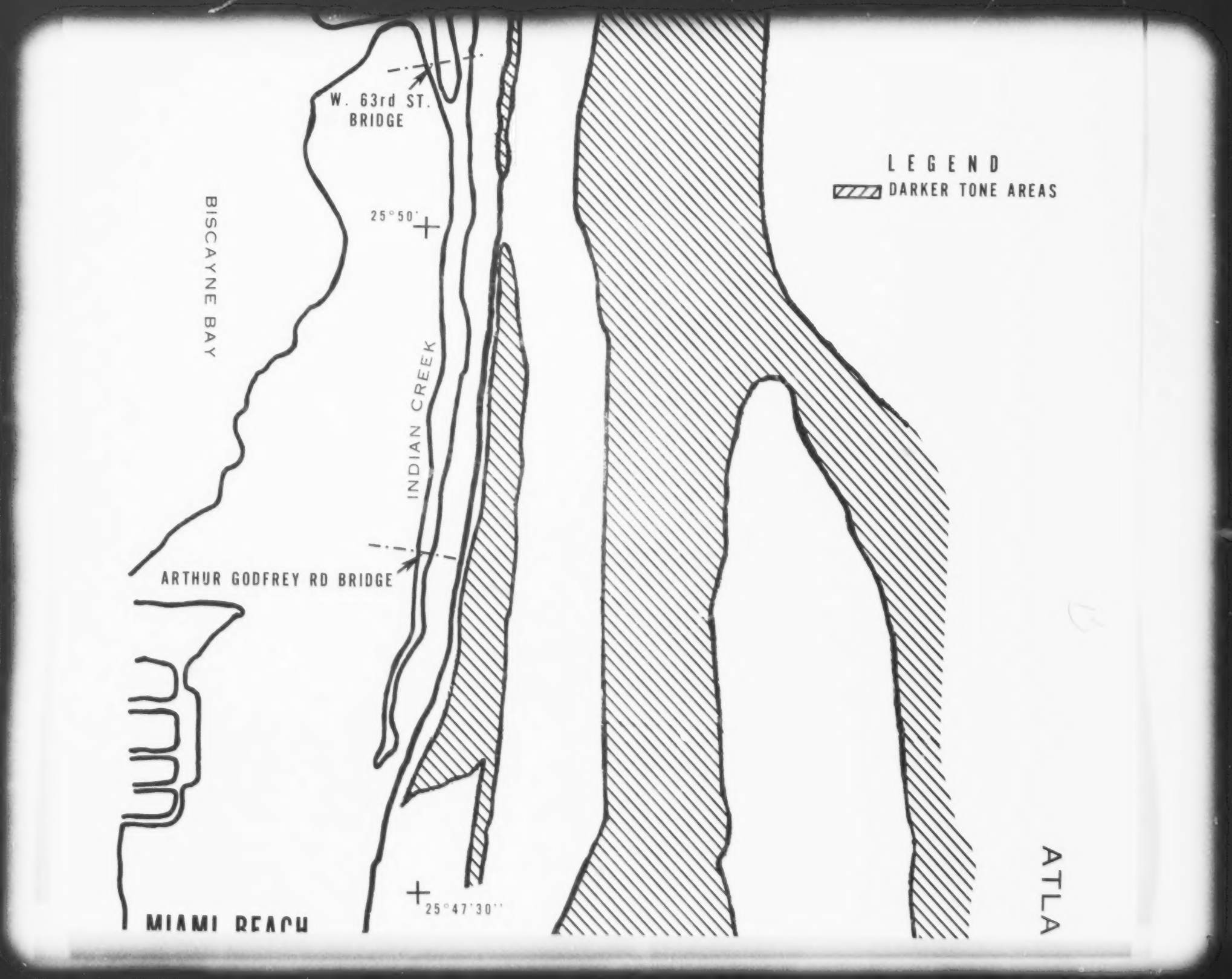


Figure 24-G. Darker Tone Areas on the Ocean Bottom


25°52'30''
71st ST.
BRIDGE
NORMANDY ISLE
W. 63rd ST.
BRIDGE
25°50'
BISCAYNE BA
N
LEGEND
DARKER TONE AREAS


W. 63rd ST.
BRIDGE
25°50'
BISCAYNE BAY
INDIAN CREEK
ARTHUR GODFREY RD BRIDGE
25°47'30"
MIAMI BEACH
LEGEND
DARKER TONE AREAS
ATLA

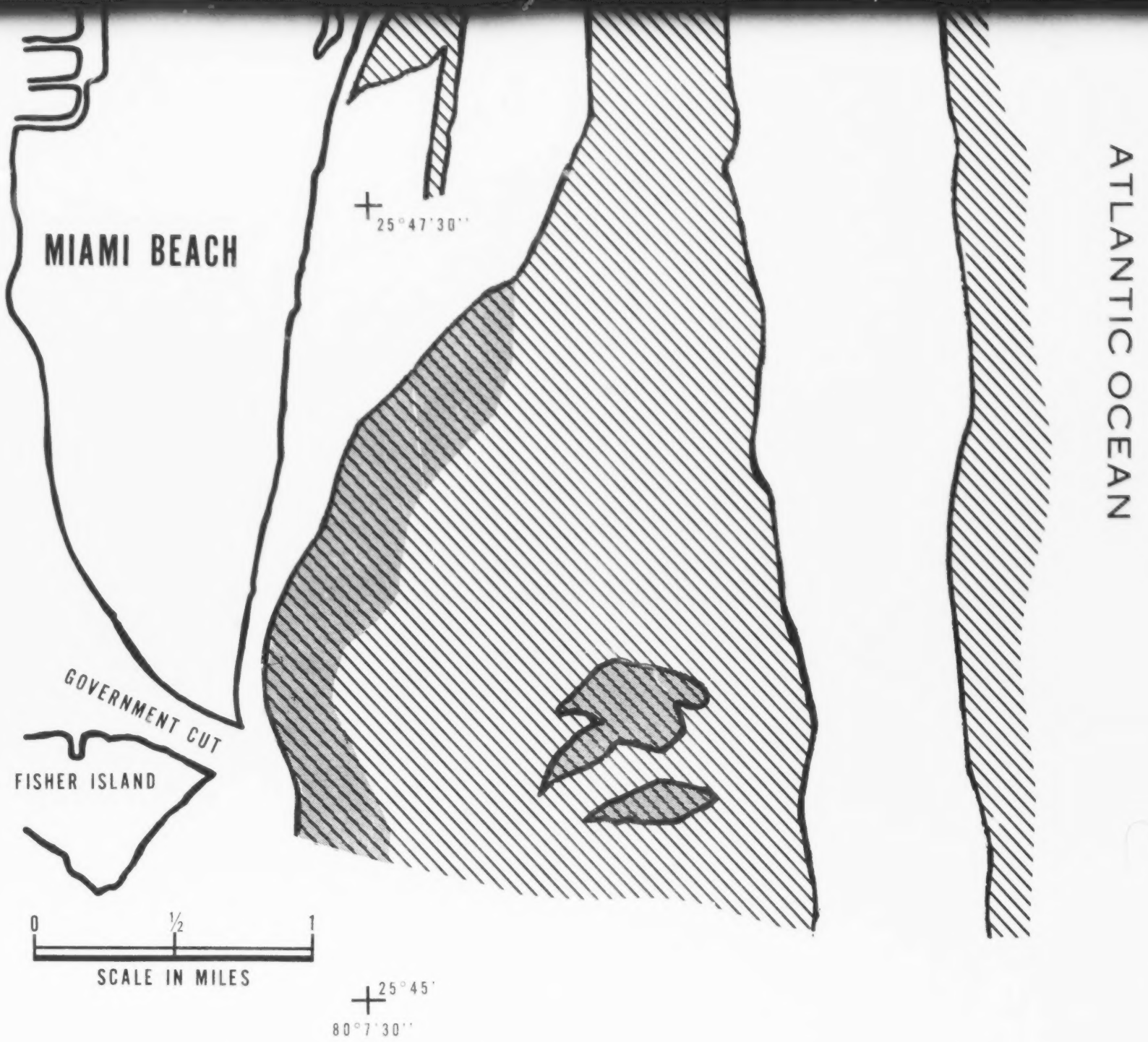


Figure 24-H. Darker Tone Areas on the Ocean Bottom

DROGUE STUDY

The Hollywood sewage outfall was selected as the site for the drogue study. The terminus for the outfall is 9,700 feet from shore and at a depth of 90 feet, and the sewage flow is reported as 13 million gallons per day.

Three drogues, each at a different depth, were set adrift in the outfall's upwelling. A different colored surface panel was affixed to each drogue for identification purposes. The color of the panels and the drogues' depth were as follows:

White surface panel - drogue at minus 10 feet

Yellow surface panel - drogue at minus 30 feet

Orange surface panel - drogue at minus 60 feet

Figure 25 is a sketch of the drogues used.

To serve as a stationary reference point, a 16-foot by 4-foot yellow float was stationed 100 feet south of the outfall's upwelling.

Seven photographic passes were made over the drogue study area in a total elapsed time period of 54 minutes 7 seconds. The orange panel drogue, at minus 60 feet, submerged and was lost after the third pass. The remaining two drogues were traced through the seventh pass. The white panel drogue traveled 5,000 feet and the yellow panel drogue 4,250 feet from the point of release. The general direction of movement was Northward with a tendency to drift toward the coast. Figure 26 illustrates the compilation of vector and movement of the drogues as recorded in each photographic pass. The associated data from these photo passes are presented in Table 1 (following).

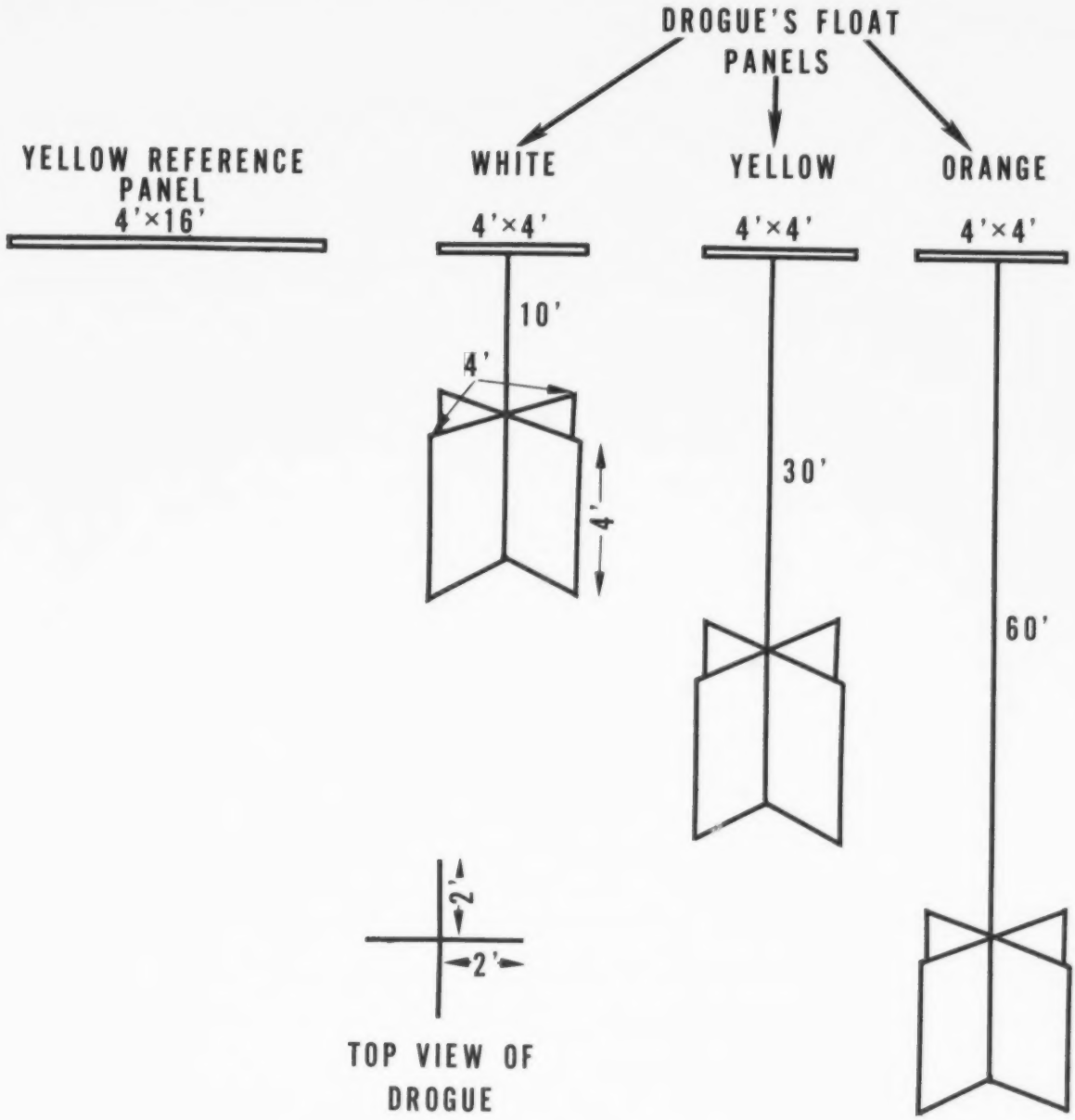


Figure 25 Drogues to Measure Different Depth Currents

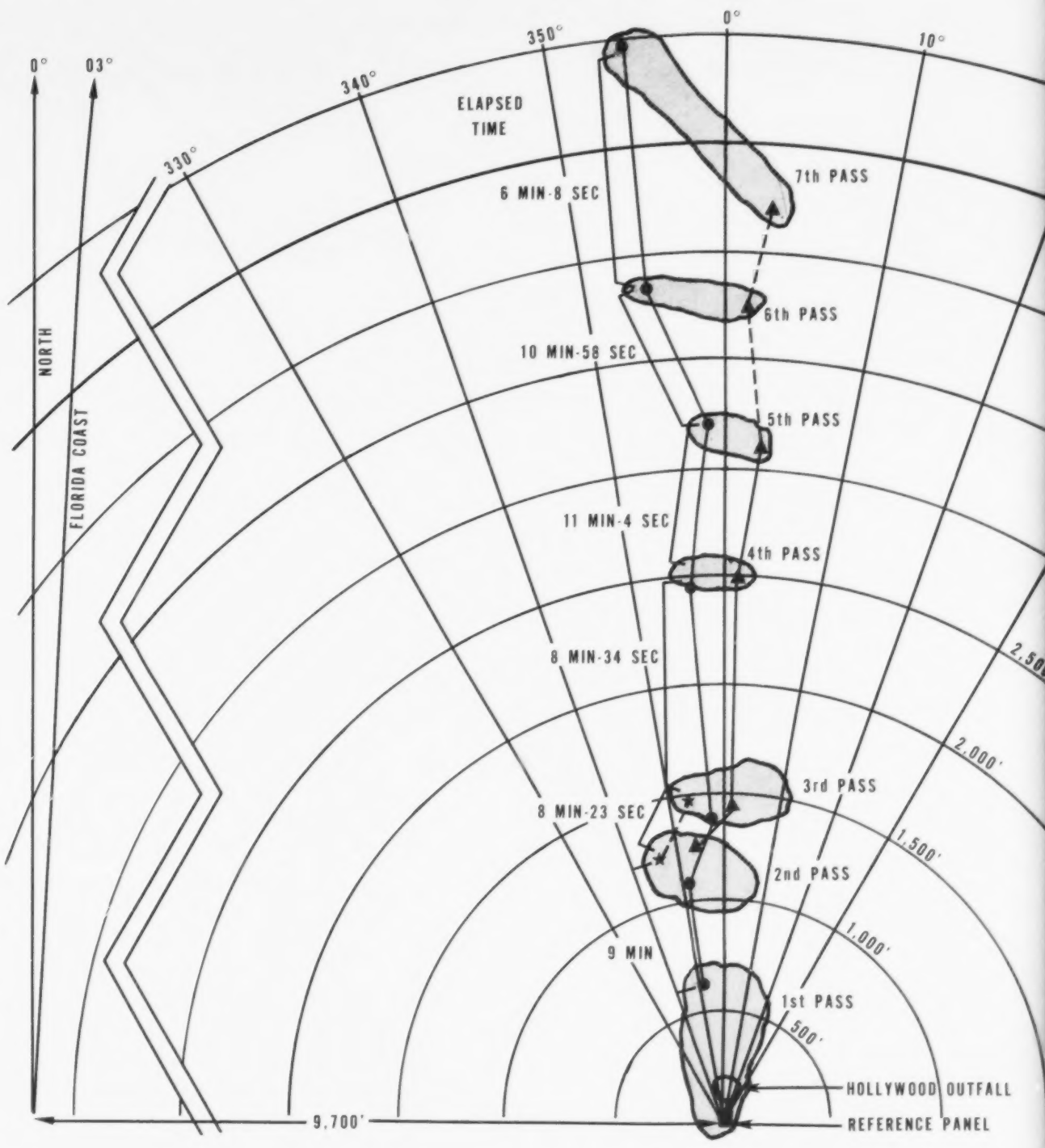


Figure 26 Drogue Vector Chart

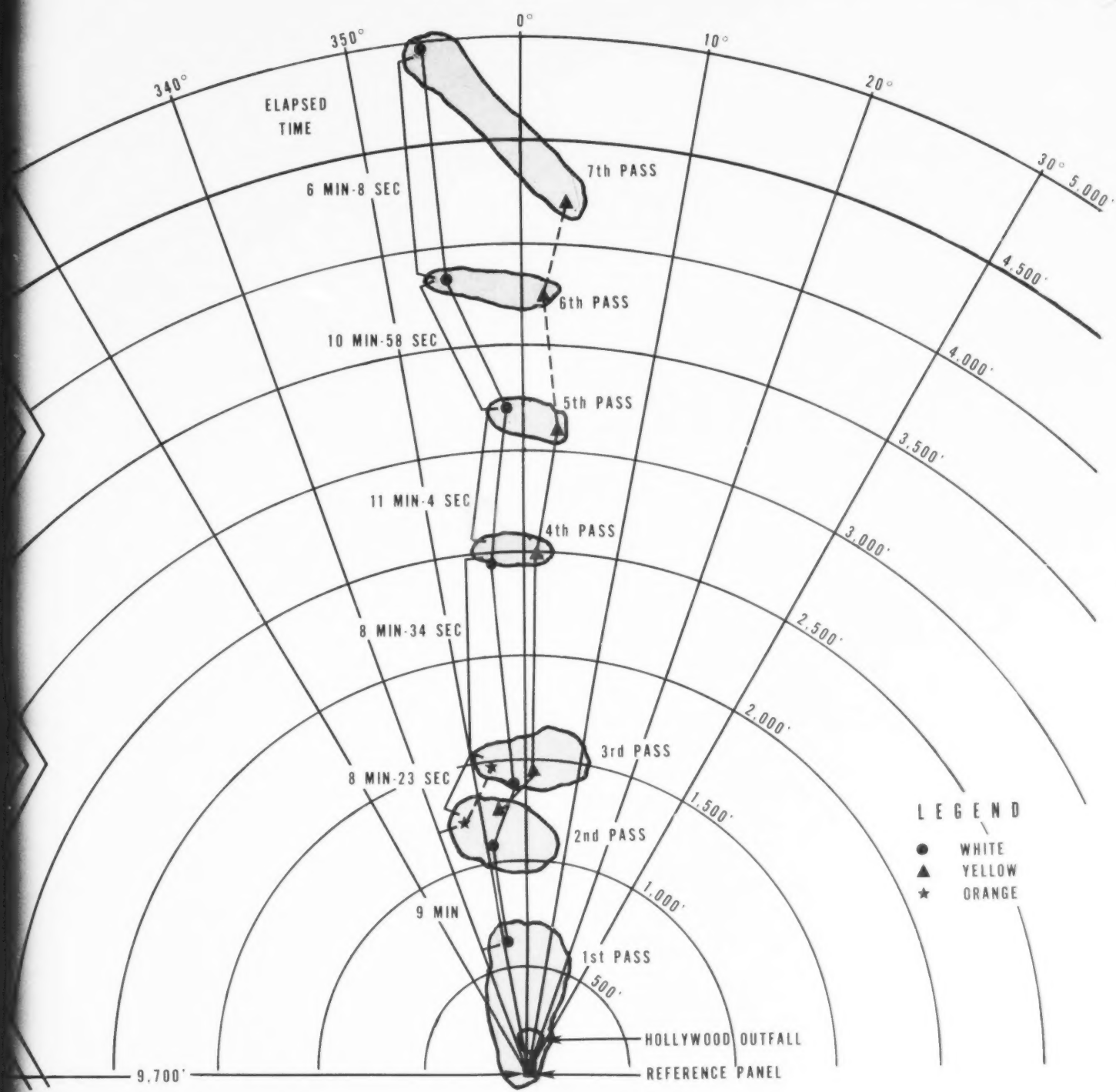


Figure 26 Drogue Vector Chart

FLIGHT PASS				WHITE DROGUE -10'				YELLOW DROGUE -30'					ORANGE DROGUE -60'				
No.	Time	Flt. Time	Lapse Time	HDG	Total Dist.	Lapse Dist	Total KTS	Lapse KTS	HDG	Total Dist.	Lapse Dist.	Total KTS	Lapse KTS	HDG	Total Dist.	Lapse Dist.	Total KTS	Lapse KTS
1	11/29/5	0	-	350°	600'	-	-	-	-	-	-	-	-	-	-	-	-	-
2	11/38/5	9 min	9 min	350°	1100'	500	.54	-	354°	1265'	-	1.38	-	345°	1245	-	1.36	-
3	11/46/28	17 min 23 sec	8 min 23 sec	01°	1410	410	.516	.483	01°	1480'	215	.84	.25	352°	1480	235	.84	.27
4	11/55/2	25 min 57 sec	8 min 34 sec	356°	2475'	895	.90	1.03	02°	2500'	1090	.95	1.25	-	-	-	-	-
5	12/06/06	37 min 01 sec	11 min 4 sec	358°	3220'	720	.859	.642	03°	3100'	725	.82	.64	-	-	-	-	-
6	12/17/04	47 min 59 sec	10 min 58 sec	354°	3850'	630	.792	.567	01°	3740'	640	.76	.57	-	-	-	-	-
7	12/23/12	54 min 07 sec	6 min 08 sec	354°	5000'	1150	.912	1.85	03°	4200'	460	.76	.74	-	-	-	-	-

White Drogue Depth = -10'

Yellow Drogue Depth = -30'

Orange Drogue Depth = -60'

Lapse - Indicates occurrence since last pass

KPH = Knots per hour in direct line distance from reference float

HDG = Heading in degrees from reference float at the Hollywood Outfall with respect to due North

TABLE I

MIAMI RIVER

The Miami River enters the Northwest section of Miami city and flows through the city in a southeast direction into Biscayne Bay. The average width of the river in the study area is 200 feet, and the predominant color of the river water was a dark grayish-brown. There were many boats docked along both sides of the river and a substantial number of water-craft service facilities. The Miami River displayed characteristics of very low dissolved oxygen content. The South Fork Miami River contained very turbid water. Listed numerically, starting at the mouth of the Miami River and moving upstream, suspected outfalls and sources of pollution are identified as follows (refer to Figure 2 for map correlation).

1. On the North side of the river and from under the Miami Avenue bridge an outfall discharging a yellowish-brown effluent was seen. The plume from this outfall varied between 15 and 20 feet in width as it flowed downstream 40 feet. At this point, water traffic had churned up the water precluding any further measurements.
2. On the North side of the river and 400 feet upstream from the Flaggler Street bridge (near the foot of Northwest 1st Street) there was a large underwater outfall. The yellowish-brown effluent from this outfall was discharging with sufficient force to push it 220 feet across the river where the plume tended to disperse among the many boats docked along the Southern bank. As the plume passed mid-river, it spread up and down the river to a width of 200 feet. There was no surface-boil associated with this outfall.

3. There was a small subsurface outfall at the down-river corner of the Scottish Rite Cathedral's parking lot at Northwest North River Drive and Northwest 4th Street. The Plume from this outfall was 6 feet at its widest point, and was dispersed within 45 feet from its source.
4. On the North bank of the river and 700 feet downstream from the 7th/8th Avenue bridge was submerged outfall. The bluish-green discharge from this outfall could be seen as far as 360 feet downstream from its source.
5. On the North bank, 75 feet downstream from the 12th Avenue bridge was another subsurface outfall. A 25-foot greenish-brown plume was visible in this area.

Heavy water traffic between the 12th and 17th Avenue bridges churned up the river water. The water disturbance was sufficient to make obscure the location of any subtle outfalls in this stretch of the river.

6. From a point 275 feet upstream on the South Fork of the Miami River a blue-green substance could be seen on the water. This substance covered a surface area 10 feet wide and could be traced downstream along the eastern bank to the confluence of the South Fork with the Miami River. A 50-foot houseboat and a 45-foot boat were tied up to the shore directly above the point where this substance first appeared. The exact source of this effluent could not be identified.
7. The green turbid water of the Tamiami Canal was flowing across the Miami River and being deflected off the northern bank of the river and downstream. The outflow from the canal was dispersed 650 feet downstream from its confluence with the Miami River.

8. The yellowish-brown water from Palmer Lake dispersed into the Miami River immediately with no plume visible.
9. A yellowish-green, irregular 50-foot plume was seen along the Southern shore of Palmer Lake 450 feet away from the South River Drive bridge. Trees growing along the shore of the lake prevented location of the outfall. A 22-foot boat was submerged 30 feet west of the plume.
10. At the Western end of Palmer Lake there were two pipelines, supported by floats above the water, discharging a liquid into the lake. The diameter of the pipes was less than one foot. There were no plumes associated with the outflow from these pipes.
11. Opposite the reveted dock area, at the foot of 31st Street on the Southern bank of the Miami River, is a building associated with a barge repair facility. Directly in front of this building was a sunken barge.
12. On the Southern side of the river immediately downstream from the Curtiss Parkway was a cove, from which a yellowish-brown effluent was entering the Miami River. This effluent could be traced 4,000 feet downstream in the Miami River. Heavy tree foliage masked the source of this effluent.

West 4th Avenue Canal

As shown in Figure 3, the West 4th Avenue Canal runs from North to South in the Western part of the City of Miami. The canal empties into the Miami River 7.7 miles upstream from Biscayne Bay near the intersection of West 4th Avenue and West 9th Street. The width of the canal is approximately 40 feet and the predominent color of the water is a dark grayish-brown. Although not shown in Figure 3, there are 28 bridges crossing the canal in irregular intervals ranging from 150 feet to 1,900 feet. In the portion of this canal, North of the Little River Canal, the water level was slightly elevated above the passageway beneath the bridges. This indicates that the flow of water is stopped or restricted in the vicinity of the Little River Canal. At the time of flight a Southwest wind had caused large mats of green algae to harbor in the Northern end of the inter-bridge canal sections which are North of the Little River Canal. The algal mats indicate a high nutrient level in the canal water, and a high potencial organic load if respiration or decay of these mats were to occur. There were no outfalls detected along the portion of the West 4th Avenue Canal encompassed within the study area.

Card Sound

Card Sound is directly South of Biscayne Bay and is situated between the mainland of Florida and Key Largo. The water in the Sound is clear and appears to be of relatively good quality. The average depth of Card Sound is only 8 feet. Figure 27 shows the location of the Florida Power and Light Company power station on Turkey Point in Biscayne Bay and the route its discharge canal takes into Card Sound. The depth of this discharge canal is 20 feet, and where the canal enters Card Sound it is approximately 195 feet wide. An area as wide as the canal and extending out into Card Sound for 200 feet has been excavated to make an incline from the bottom of the canal up to the bottom of Card Sound. Extending another 380 feet out into the Sound is an area where the tide, current, or outflow from the canal has spread some of the loose spoil from the excavated area (refer to Figure 28).

The imagery recorded over the study area is of good quality and the bottom of Card Sound is clearly seen.

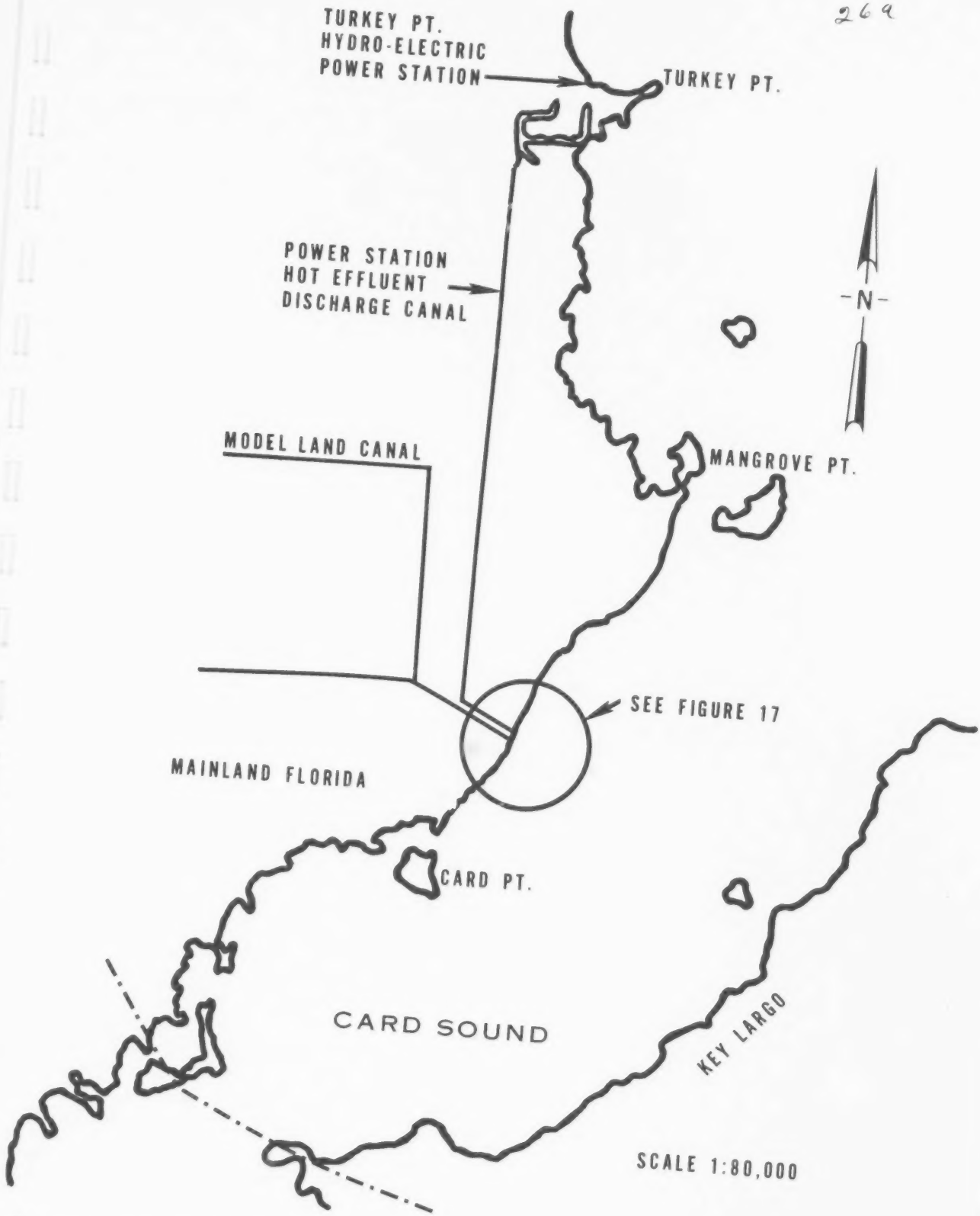


Figure 27 Turkey Point Power Station and Discharge Canal

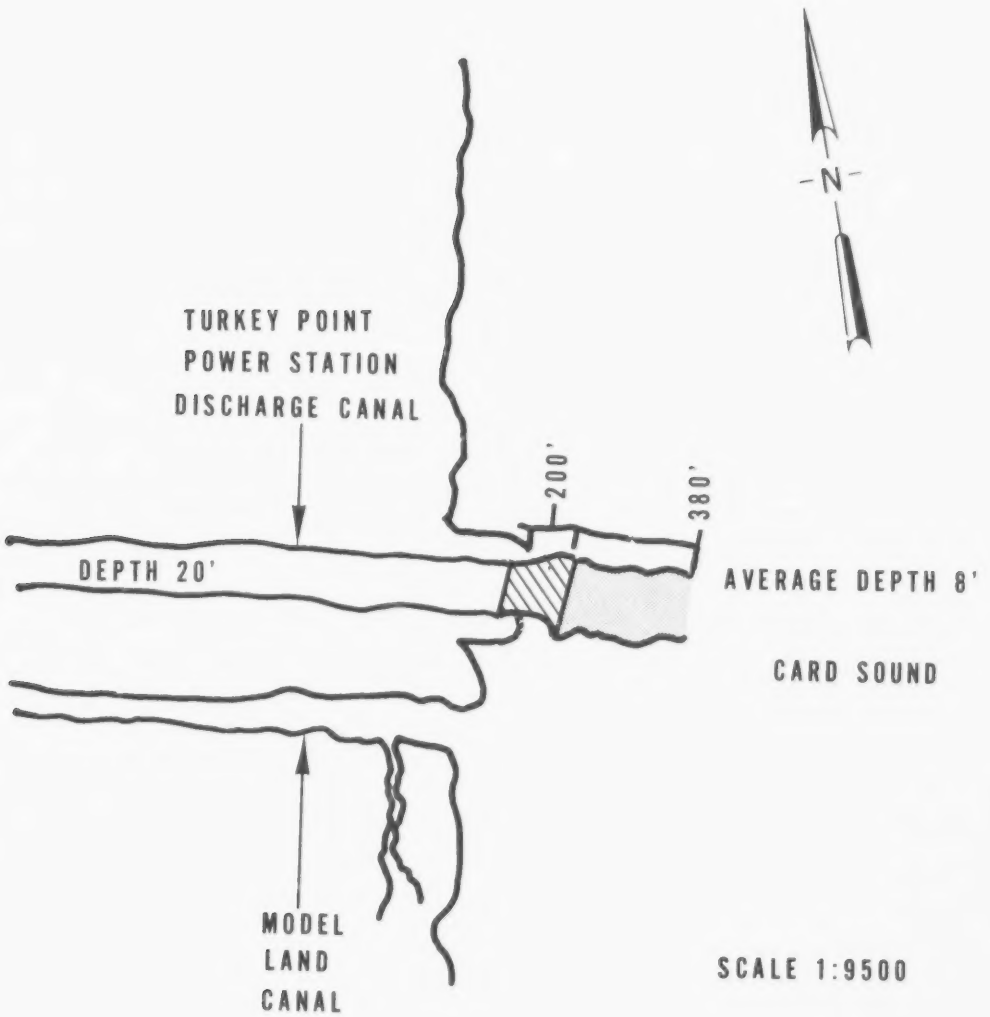


Figure 28 Turkey Point Power Station Discharge Canal Into Card Sound

APPENDIX

Focal Length, Angle of View, and the Effects of Focal Length and Altitude

The focal length of the aerial sensors affects the size (or scale) of the resulting imagery. At any given altitude, the image size changes in direct proportion to changes in focal length. Also for a given focal length, the image size is inversely proportional to the altitude.

The angle of view of a sensor is a function of the focal length and the image format size. The importance of the angle of view is its relationship to the amount of target area recorded in the imagery. Refer to the following diagrams: A. Focal length of a simple lens. B. Effect of focal length on scale and ground coverage. C. Effect of altitude on scale and ground coverage.

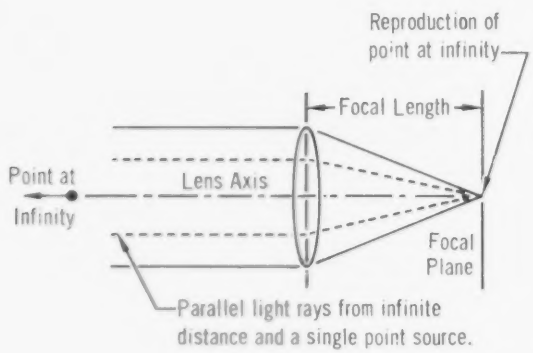


Diagram A. Focal Length of a Simple Lens

Focal length is the distance from the lens (A) to the film (B).

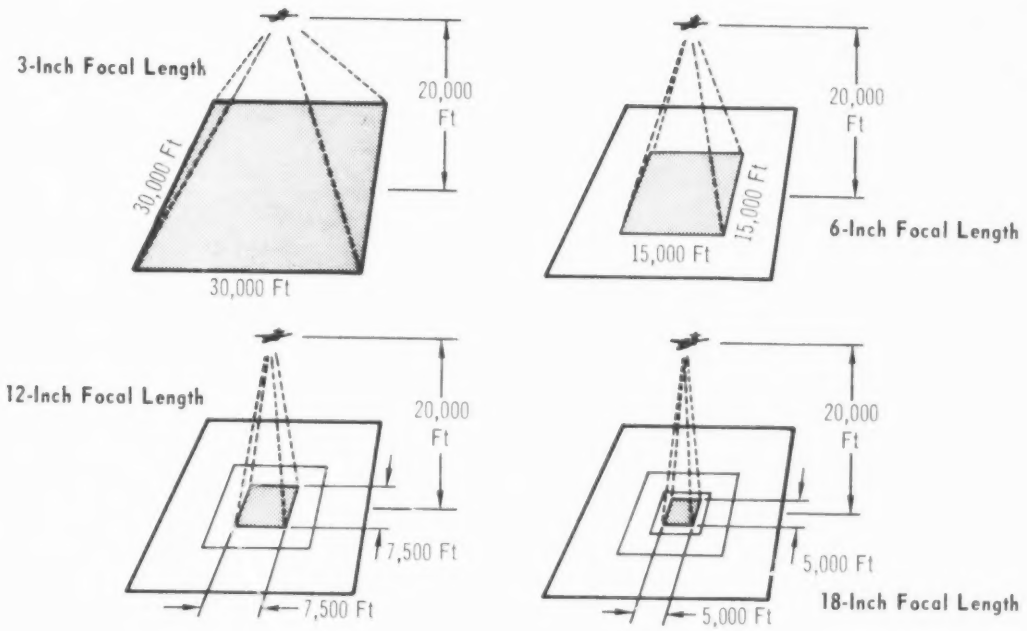


DIAGRAM B Effect of Focal Length on Scale and Ground Coverage

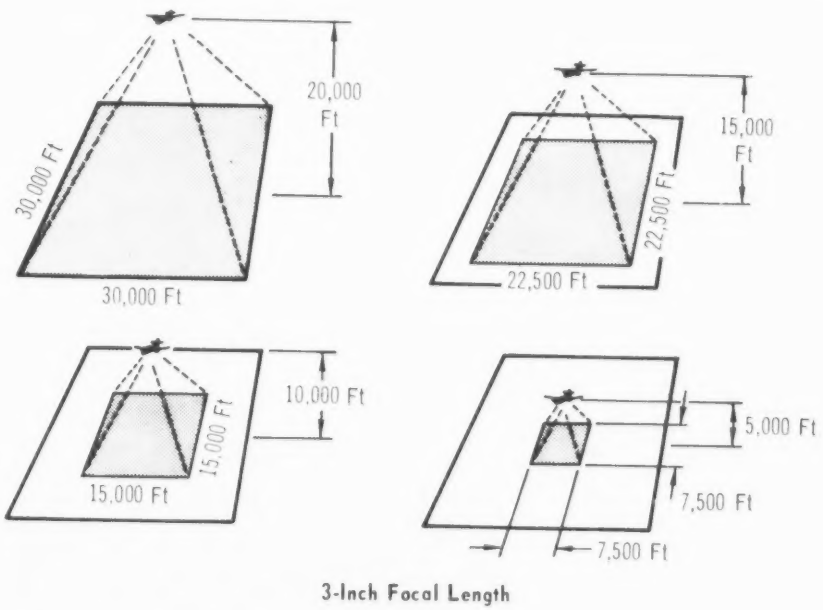


DIAGRAM C Effect of Altitude on Scale and Ground Coverage